NeTIRail

Needs Tailored Interoperable Railway Infrastructure

Deliverable 1.6

Wider economic benefits final report

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Executive Summary

This overall aim of this deliverable is to set out the methods to quantify and value the wider economic impacts of the NeTIRail-INFRA interventions which form the basis of the business case for the case study lines in task 1.6.

Within this there are three key objectives:

1. The presentation of appropriate models for quantification of economic output and productivity impacts as derived from a survey of the literature
2. The development of a model to quantify the relationship between rail infrastructure and employment focused around the NeTIRail-INFRA interests (busy commuter line, low trafficked line and freight line in the East European countries Slovenia, Romania and Turkey).
3. The presentation of appropriate valuation methods for all the economy impacts as derived from a survey of the literature.

Before wider economic impacts can be valued in a cost benefit analysis it is necessary to predict the scale of the impacts on the economy – e.g. in terms of productivity, employment and output. This is the quantification stage and is addressed through objectives 1 and 2. As part of this process we identify the market failures that are relevant to the analysis, as this determines the scope of the wider impact analysis to be employed in the NeTIRail-INFRA case studies.

Through objective 2 this deliverable also addresses one of the main evidence gaps in the quantification of wider economic benefits – that of quantifying the employment effects. Within this deliverable we present new evidence on the relationship between rail infrastructure and employment. Whilst we were unable to identify suitable historic investments within all the NeTIRail-INFRA area of interest, we proceeded with a detailed examination of four historic rail investments: Murska Sobota- Hodos (Slovenia), Mansfield to Nottingham - the Robin Hood line (UK), Manchester metro (UK) and Stirling to Alloa (UK) which covered busy commuter lines and low trafficked lines.

Our analysis of these case studies in this deliverable has given interesting but mixed results. We do find evidence of employment impacts in certain contexts but these have been hard to interpret in the context of the NeTIRail-INFRA innovations and thus objective 2 is not entirely met. This deliverable nevertheless sets out the principles for quantifying employment impacts based on existing evidence and guidance necessary to estimate such effects where relevant for the innovations, utilising the general evidence from the literature as well as the new econometric work undertaken.

In terms of the valuation stage addressing objective 3, economy impacts are only included in a cost benefit analysis in addition to transport user benefits in certain circumstances. In these circumstances transport user benefits do not capture all the social benefits of a transport investment. For the NeTIRail-INFRA business case studies we identify the relevant conditions as agglomeration economies; some degree of imperfect competition in the general economy; income taxes in the labour market; and the potential that high levels of unemployment exist. This set of conditions is driven by an understanding of the NeTIRail-INFRA innovations which are primarily

aimed at improving the efficiency of operating the rail network rather than expanding the network *per se*.

In order to fully address objectives 1 and 3 related to the quantification and valuation stages we have transferred models used elsewhere to capture the agglomeration impacts and imperfect competition effects. Suggested model parameters pertinent to Eastern Europe have been drawn from the literature and presented to give a set of models that can be used to estimate the wider economic impacts of the NeTIRail-INFRA innovations when tested in the case studies.

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Abbreviations and acronyms

Abbreviation / Acronym	Description
DID	Difference in Difference
GDP	Gross Domestic Product
IV	Instrumental Variables
SMS	Scientific Maryland Scale
GVA	Gross Value Added
NUTS1/2/3	EUROSTAT Nomenclature of Territorial Units for Statistics NUTS1 – Major socio-economic regions NUTS2 – Basic regions for the application of regional policies NUTS3 – Small regions for specific diagnoses

1. Introduction

1.1 Wider economic impacts

Wider Economic Impacts are the economic impacts of transport (e.g. on labour, product and land markets) that are additional to the transport user benefits (e.g. travel time savings). Under conditions of perfect competition for both the transport and transport-using sectors, a properly specified appraisal of a transport scheme would accurately estimate all welfare impacts through the first order effects (i.e. user benefits as measured by consumer surplus). These first order effects are estimated in Task 1.3.2. In practice, most markets are not perfectly competitive. If only direct user impacts are appraised, some economic impacts would be missing. In some contexts, these impacts can be a large part of the overall appraisal of a rail scheme.

The development of a methodology for estimating wider impacts and incorporating them into project appraisal is still an emerging field. A degree of consensus has developed. The direct benefits of a transport project (the time, cost and journey quality user benefits) drive changes in the wider economy. When the broader economy functions very well these benefits are fully passed through to the wider economy, and changes in the wider economy feedback to transport users. In such a situation including both transport user and provider benefits in a cost benefit analysis and benefits to employment, changes in land use, etc. would double count the benefits. However, if the wider economy is not completely efficient, transport users and operators will not be able to capture all the social benefits of a transport project. In this situation there is a need to include wider economic benefits in the cost benefit analysis in addition to the transport benefits. Economists term the sources of inefficiency as ‘market failures’. It is these market failures that prevent the transport users fully capturing all the social benefits. Some of these market failures might be construed as policy failures such as a lack of affordable housing which may result in an immobile workforce creating pockets of high unemployment (structural unemployment). Others are naturally occurring and are not usually seen as policy failures, but just a form of natural law. Productivity gains through agglomeration are one of those. The actions of one person (choosing to work in a city instead of the countryside) benefits all other workers in the city through the process of increasing productivity via increasing the size of the agglomeration. Another is the manner in which businesses try to differentiate their products from their competitors leading them to be able to increase profit margins. There is a further group of so called ‘failures’ that are there by policy design– such as a labour tax on earnt income or minimum wage legislation. These are socially desirable and are not construed as failures by the broader public – in fact quite the opposite, so labelling them as failures seems inappropriate. The consequence of any of these so called ‘market failures’ occurring is that transport users and providers will not capture the full social benefits of a transport project, and to fully measure the full social benefits one needs to also include wider economic benefits in the analysis. Which wider economic benefits to include in an analysis is clearly dependent on how the transport project affects the local economy and what forms of ‘market failure’ exist in that economy.

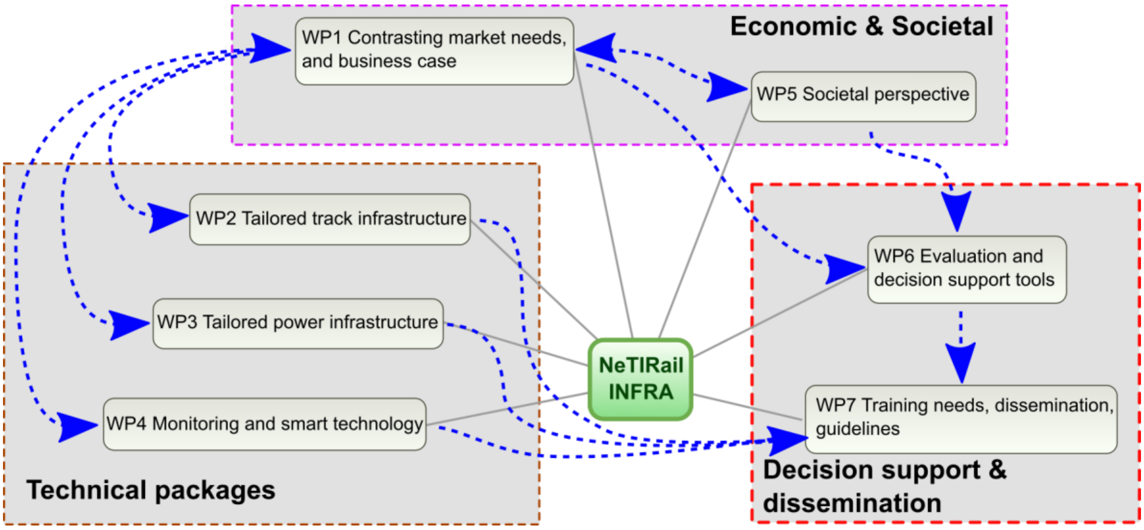
Improvements in links between cities for passenger and freight can potentially yield all of the identified impacts. However, agglomeration impacts are more likely when the links between two large cities can be improved, facilitating economies from larger labour and supplier pools and larger consumer markets. It is less likely that an improved feeder line from a rural area to a city will yield significant agglomeration impacts but could lead to wider economic benefits through increases in labour supply, better skills matching and increased output. If the remoter area also suffers from high levels of unemployment then this will also be a source of additional benefit. Thus the context of the case studies is important in determining the appropriate forms of wider impacts which need to be considered. The case study lines have been described in D1.1.

1.2 Scope of Task 1.4

1.2.1 Relationship to other tasks in NeTIRail-INFRA

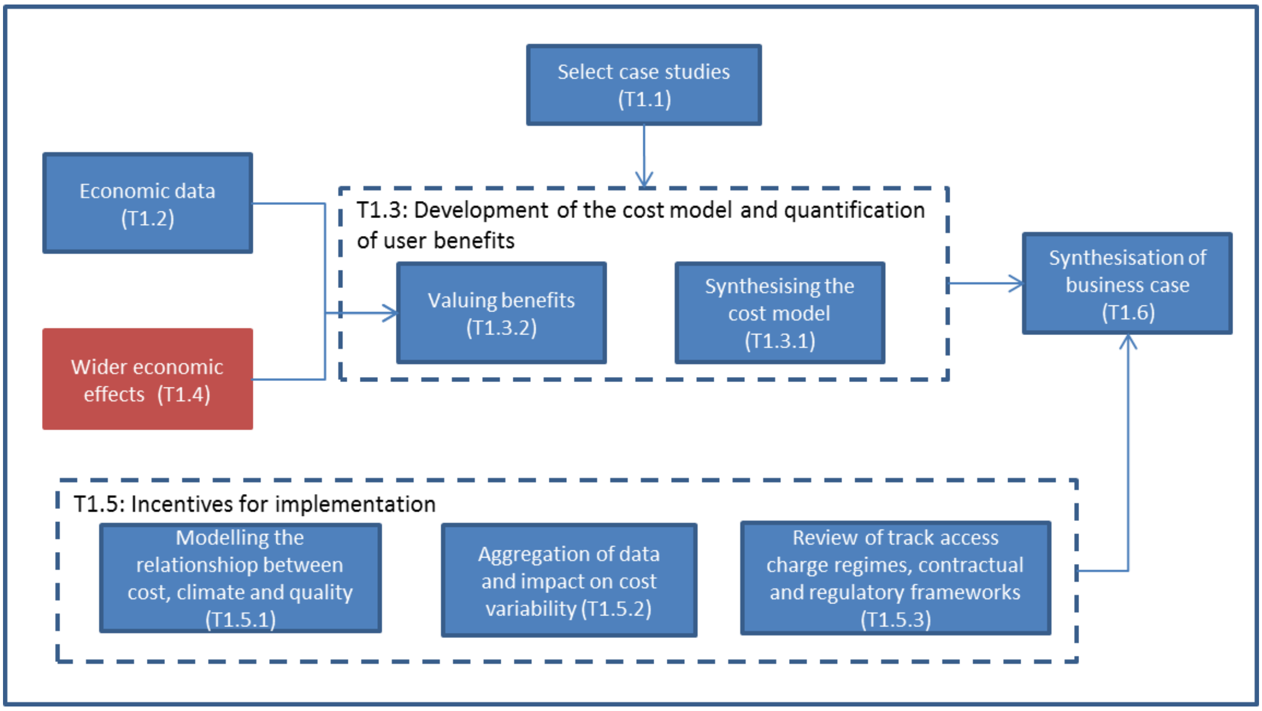
Task 1.4 (Wider Economic Benefits) in NeTIRail-INFRA is concerned with the development of the tools required to estimate the wider economic impacts of the case study rail lines. These estimations will form part of the business case for the innovations developed in work packages 2, 3 and 4 and will where possible be incorporated into the decision support tools being developed in WP6. The tools themselves will be applied as part of Task 1.3 (Valuation of Benefits) and will sit alongside the analysis of societal impacts (Work Package 5) and will ultimately be incorporated in the decision support tools (work package 6). Figure 1 shows a schematic of this.

Figure 1: Relationship between work packages of NeTIRail-INFRA



Within Work Package 1 there are six tasks – see Figure 2. Task 1.4 (wider economic effects) provides the ‘tools’ that will calculate the wider economic benefits estimated in Task 1.3.1 (benefit valuation) and appearing in the synthesised business case (Task 1.6).

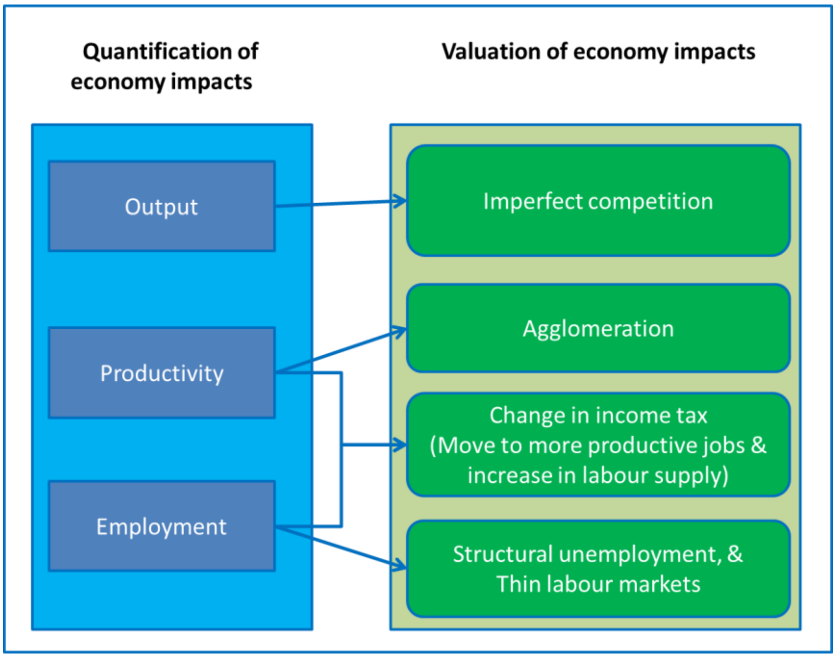
Figure 2: Relationship of Task 1.4 to other tasks within WP1



1.2.2 Report Objectives

Within Task 1.4 (wider economic effects) there are two distinct elements: quantification and valuation (see Figure 3). There is a quantification stage in which the scale of the impacts on the economy – e.g. in terms of productivity, employment and output – are assessed. This is represented by the left hand column in Figure 3. The literature is quite developed in the context of changes in productivity and its relationship with economic mass and there is also a large literature on the relationship between transport infrastructure and output in the aggregate. However, the literature remains fairly embryonic in terms of estimating employment impacts from changes in transport quality.

Figure 3: Scope of Task 1.4 wider economic effects



The second stage is concerned with the monetary valuation of the quantified changes in the wider economy within the cost benefit analysis. The additional social value of the changes in the economy are clearly a function of the size of the market failure. Thus it is quite possible to have large changes in an economy, but only a small level of additionality, and contrastingly small changes in an economy but a large level of additionality. In terms of valuation here the literature is also well developed – with regard to how to value productivity due to agglomeration, labour supply impacts and impacts on unemployment. This is represented by the right hand column in Figure 3.

The overarching purpose of this deliverable is to set out the methods to quantify the economic impacts of the NeTIRail-INFRA interventions and then value them within a cost benefit analysis framework – which forms the basis of the business case in task 1.6 (see Figure 2). As part of this process of addressing the wider impacts there is a need to identify the market failures that are relevant to the analysis, as this determines the scope of the wider impact analysis to be employed in the NeTIRail-INFRA case studies.

This deliverable also addresses one of the main evidence gaps in the quantification of wider economic benefits – that of quantifying the employment effects. Within this deliverable we present new evidence on the relationship between rail infrastructure and employment. Ideally this would have focused exclusively around the NeTIRail-INFRA interests (busy commuter line, low trafficked line and freight line in the East European countries Slovenia, Romania and Turkey) using interventions with some similarities to those proposed by NeTIRail-INFRA. We identified a long list of potential employment case studies in the wider economics interim report (D1.5) which included lines in Romania, Turkey and Slovenia. As detailed in D1.5, we scrutinized these lines further and developed a short list based on identifying historic rail investments that:

- Map onto the case study line types: busy commuter line, low trafficked line and freight line;
- For which data that can support an evaluation exists;

- That have been open sufficiently long for employment impacts to be observed; and
- Are ideally situated in the case study countries (Slovenia, Romania and/or Turkey)

D1.5 short listed seven projects for further investigation (3 UK, 3 Sweden and one from Slovenia, as shown later in this report in Table 2). Due to lack of suitable case studies or data we rejected the Romanian and Turkish long-listed case studies. Upon further investigation we proceeded with a detailed examination of four historic rail investments: Murska Sobota- Hodos (Slovenia), Mansfield to Nottingham - the Robin Hood line (UK), Manchester metro (UK) and Stirling to Alloa (UK). The results of this detailed econometric work is reported in this deliverable. This new econometric work advances the literature and understanding in this area - here our focus is twofold. Firstly on developing some evidence that could be used in the NeTIRail-INFRA business cases and secondly on developing the literature on the ex-post evaluation of wider economic impacts, particular in respect of effects in the labour market – where there is currently a gap in the literature.

With respect to the first objective this has been particularly challenging to achieve as we were unable to identify suitable historic investments within the NeTIRail-INFRA area of interest. Notwithstanding that, a set of projects which delivered significant changes in accessibility were identified. If they had showed a clear consensus on the employment impacts of rail schemes this may have allowed some transfer of findings to the NeTIRail-INFRA business cases. The results are interesting but quite mixed and, whilst an important research outcome, make a transfer of the findings to the NeTIRail-INFRA business cases difficult. This deliverable nevertheless sets out the principles necessary to estimate such effects where relevant for the innovations, utilising the general evidence from the literature as well as the new econometric work undertaken, as well as reporting the results of these investigations.

1.3 Report Structure

Following this introductory chapter, Chapter 2 discusses the economy impacts of most relevance to NeTIRail-INFRA. Chapter 3 then describes the methods used to quantify the economy impacts. Included within this is a description of the econometric work. Included within this section (3.3.3 to 3.3.8) are the ex-post employment case studies which contain a detailed description of the empirical work examining the employment effects of rail lines. This work feeds into the quantification methodology for employment impacts. Chapter 4 sets out the methods to be used to value the economy impacts, whilst the final chapter, Chapter 5, brings the report to a conclusion.

2. Identification of market failures

A number of countries have been at the forefront of the inclusion of wider economy methods in economic appraisals, one of which is the UK. Whilst there is a degree of consensus on the sources of additionality, as yet there appears to be no consensus in the literature on how and which wider economy impacts of a transport initiative should be included (Wangsness et al., 2017). We therefore follow Laird and Venables (2017) who propose a general framework within which an economic appraisal can be considered. They suggest that in the context of proportionate appraisal one should focus on the impacts that are most relevant to the transport initiative in question. One therefore needs to have an expectation on the economic impacts of the transport initiative and then identify relevant market failures from there. As discussed in the introduction this is because it is only in the presence of market failures that transport user and provider benefits do not full capture all the social benefits of a transport investment and there is then the need to value economy impacts in the economic appraisal.

In the main the proposals under consideration by NeTIRail-INFRA will improve the delivery of services through cost decreases and improvements in reliability. The initiatives are concerned with improvements to existing infrastructure rather than the delivery of new railways or new stations. The emphasis therefore is on the encouragement of economic growth through improving accessibility (in its broadest sense) rather than opening up new land for development or specifically aiming to change land uses. Transport is not in this instance an overly constraining force on growth.

Using Laird and Venables' typology (see Table 1) this would suggest the core economic impacts will arise from changes in cost directly benefiting businesses and households (the user benefits). As we are not expecting significant changes in land use, the changes in accessibility will also lead to changes in productivity due to agglomeration primarily through static clustering effects –i.e. a reduction in generalised travel costs reducing temporal rather than physical distances between firms and workers. Related to that we would expect increases in economic output to be primarily driven from increased productivity – more efficient use of time and increased productivity through agglomeration. There may be some displacement from areas outside the vicinity of the scheme as firms who benefit from the initiatives will out compete firms who do not benefit directly. Finally we would expect some changes in employment as the transport initiatives improve commuting opportunities (drawing more people into the labour market) and will improve business performance leading them to recruit more workers.

These economy effects only have relevance in a cost benefit analysis should there exist market failures. There are no relevant market failures associated with user benefits, but in the NeTIRail-INFRA context there do exist market failures associated with:

(1) Increased productivity from agglomeration. The actions of one person (choosing to work in a city instead of the countryside) benefits all other workers in the city through the process of increasing productivity via increasing the size of the agglomeration. Technically, the agglomeration externality represents an external economy of scale from increased economic activity not captured in commuting user benefits. There may be positive externalities to firms and households from an increase in the variety of products available

(2) Increased output due to the presence of imperfect competition in product markets. The manner that businesses try to differentiate their products from their competitors leading them to be able to increase profit margins results in a degree of imperfect competition. In these markets, price exceeds marginal cost, so firms receive extra profits from any additional output over and above the pure cost savings captured in any business time savings..

(3) Changes in employment due to labour taxes. As discussed earlier labour taxes are important to government but are technically construed as a market failure'. A labour tax drives a wedge between the wage the firm is willing to pay and the wage the worker makes their supply decision based on. This wedge represents an additional benefit in the form of extra tax revenue for the government following any employment increase or movement to more productive work stemming from commuting cost reductions,

(4) Potentially high levels of unemployment. There are many sources of unemployment but a lack of mobility caused but a lack of affordable housing is one (clearly a policy failure) and minimum wages

(which is arguably socially desirable) are another. If involuntary unemployment exists, the market clearing wage lies and employment lie below their market clearing levels. This could be caused by wages being sticky downwards or the existence of minimum wages. As employment expands, the welfare benefits of the expansion are larger than the transport user benefits. Also, the presence of higher search and mobility costs can lead to a larger degree of inefficiency in labour markets. The result is that an increase in employment in thin labour markets will have an economic impact greater than that captured though commuter user benefits.

This discussion is summarised in Table 1 – with the bold text identifying the economic impacts of relevance to NeTIRail-INFRA alongside a full typology of the economic impacts and mechanisms as identified in Laird and Venables (2017).

Table 1 – Economic impact and transport-economy mechanism (cells in bold text are relevant for NeTIRail-INFRA)

Economic impact	Mechanism		Valuing	
			Welfare	National GVA
User benefits	**Firms**	**ΔGTC[1] leads to Δcost / price**	**✓**	**✓[5]**
	Households	**ΔGTC leads to Δtime/quality/cost**	**✓**	**---**
Productivity due to agglomeration	**Static (larger markets)**	**ΔEconomic mass (with fixed land uses and ΔGTC) changes productivity of all workers**	**✓**	**✓**
	Dynamic: increased employment	ΔLand use leading to Δemployment changes productivity of all workers	✓	✓
	Dynamic: clustering and increased specialisation	ΔIndustrial sector split changes productivity of workers in an industrial cluster	✓	✓
Induced Investment and land use change	**Increased output**	**ΔQ[2] x Displacement (0-100%)**	**---**	**✓[5]**
		ΔQ and imperfect competition x Displacement (0-100%)	**✓**	**✓**
	Land use change	Increased varieties/attractiveness (land use externality) x Displacement (0-100%)	✓/---[3]	✓/---[3]
	Barriers to development	Market failure in the planning regime x Displacement (0-100%)	✓	✓
		Coordination failure	✓	✓
	Multi-sectoral investment	Complementary policies reinforcing each other. Partial equilibrium analysis is inappropriate – examine land value uplift or use multi-market methods x Displacement (0-100%)	✓	✓
Employment	**Displacement of labour**	Move to more productive jobs (market failure is labour tax)	✓	---[6]
		Reducing unemployment in areas of high unemployment (market failure frictions in the labour or housing markets)[4]	**✓**	**---**
	Labour supply	**Δlabour supply function due to lowering barriers to work (market failure is labour tax)**	**✓**	**✓[5]**

Notes: (1) ΔGTC – generalised transport costs; (2) ΔQ – change in output; (3) land use externality can be related to the agglomeration externality and the analysis must be structured to avoid double counting; (4) If labour is displaced from an area experiencing similar market failures, as may be obvious from similar levels of unemployment, then displacement effects also need to be taken into account in the welfare calculation. (5) Care needs to be taken to avoid double counting GVA impacts; (6) GVA impact included in dynamic productivity effects due to changes in employment

Adapted from Laird and Venables (2017)

3. Quantification of economy impacts

3.1 Introduction

As discussed in the previous chapter the economy impacts of relevance are those associated with changes in productivity due to agglomeration (based on fixed land uses – static clustering), changes in employment (from increased commuting opportunities and business growth) and changes in output (based on the previous two economic responses plus changes in productivity from time savings – user benefits).

3.2 Productivity due to agglomeration

3.2.1 Changes in productivity

Economic activity is very unevenly distributed across space. It is inconceivable that this marked unevenness can be explained by differences in physical geography and comparative advantage (Rosenthal and Strange, 2004; Duranton and Puga, 2004; Behrens and -Nicoud, 2015; Coombes and Gobillon, 2015). The view is that over time the economic system has led to the concentration of activity to certain places above and beyond the benefits of natural comparative advantage. This is due to the benefits of clustering. Some of these benefits, known as agglomeration economies, arise due to the production advantages of physical proximity. This can be physical proximity to pure economic mass (urbanisation economies) or to proximity to similar firms (localisation economies). These aggregate benefits of proximity are driven by many micro-economic mechanisms categorised into: sharing; matching and learning mechanisms (Duranton and Puga, 2004). Transport is relevant to this discussion as changes in transport costs (e.g. through travel time savings) have the potential to change the size of agglomerations.

There has been considerable interest over the last twenty years in the size of agglomeration economies. A seminal review is that by Rosenthal and Strange (2004). This has led to the general view that a doubling of city size would increase productivity by between 4% and 11% (with an elasticity range of 0.03 to 0.08). In a meta-analysis Melo et al (2009) report an average elasticity of 0.058. There is however significant variation. In particular the service sector exhibits higher elasticities than other sectors. The method of estimation (and associated data) also has a strong bearing on the results. By taking account of unobserved worker heterogeneity (i.e. unobserved differences between individuals) estimates are lower. Coombes and Gobillon (2015) in a review of recent studies using individual level data cite elasticities between 0.01 and 0.03 – though these all relate to western European countries.

Cross-European studies seem to find higher elasticities. Brulhart and Mathys (2008) find a long run elasticity of productivity to density of 0.13 using 245 NUTS2 regions in 20 western and eastern European countries. They find that the inclusion of eastern European countries in the analysis raises the elasticity found – implying higher elasticities exist in eastern than western Europe. They in part attribute this to the manner that eastern European countries have a legacy of a centrally planned economy with productive activities concentrated around the capital. Foster and Stehrer (2009) using 255 NUTS2 regions in 26 European countries find an average (localisation) elasticity of 0.04 – consistent with the main evidence base. However when this is disaggregated between old Europe (western countries) and new Europe (eastern European countries) the elasticity for western countries drops to approximately 0.01 and that for eastern European countries is lifted to about 0.2. The implication is that there have been large effects of agglomeration in eastern Europe over the period they considered (1998-2005). Marrocu et al. (2013) also find that elasticities in eastern Europe are larger. Furthermore they find that specialisation (localisation economies) dominate in new (eastern) Europe and diversification (urbanisation economies) dominate in western European countries when explaining growth in total factor productivity between 1996 and 2007. They attribute this to the manner that old Europe is specialising in knowledge intensive industries which require diversification, whilst manufacturing activities are re-locating to new Europe which is specialising in these economic activities.

In terms of specific agglomeration elasticities pertinent to the NeTIRail-INFRA case study countries (Slovenia, Slovakia and Turkey) our searches have not identified any studies. We therefore need to transfer values from the existing evidence base. The implication from the discussion above is that for western countries the elasticity of productivity is likely to be lower than the average 0.058 found by Melo et al. (2009). However for eastern European countries the value is likely to be higher. How much higher is uncertain. There is a lack of evidence here with the only study identifying agglomeration impacts in eastern European countries that of Foster and Stehrer (2009) who find an elasticity of 0.2. Given this lack of direct evidence for the NeTIRail-INFRA business cases we would therefore propose using the average elasticity from Melo et al. of 0.058 with a sensitivity test of using the 0.2 elasticity found by Foster and Stehrer (2009) for Eastern European countries.

3.2.2 Agglomeration calculations

To quantify the impacts of changes in agglomeration we not only need an elasticity as discussed above but we also need to measure how economic density changes. In the main the studies above discuss the manner that productivity changes across Europe in the context of administrative areas. Clearly transport initiatives cannot affect the size of administrative areas. Therefore an economic density function that reflects how transport changes affect economic density is needed. A gravity model formulation is one that has been adopted elsewhere – for example in the UK. For *j* zones with each zone having employment E_j and generalised cost GC_{ij} between zone *i* and zone *j* this would give the economic density for zone *i* of:

$$Economic\ Density\ of\ zone\ i\ (ED_i) = \sum_j \frac{E_j}{GC_{ij}}$$

Generalised cost has to be a weighted composite between road and rail modes of transport ideally weighted by mode split (of business and commuting related trips[1]). In the absence of mode split data a simple arithmetic average can be used.

The percentage change in productivity due to agglomeration for zone *i* can then be calculated as the ratio of effective density after the intervention to before raised to the elasticity of productivity with respect to economic mass (α) :

$$Percentage\ change\ in\ productivity\ of\ zone\ i\ (P_i) = \left(\frac{ED_i^{After}}{ED_i^{Before}}\right)^{\alpha}$$

[1] Non-work other trips (visiting friends and family, shopping, etc) are unlikely to be relevant for agglomeration economies and therefore in a weighted calculation of generalised cost should be excluded.

The increase in output from this productivity shift can then be calculated by multiplying the percentage change in productivity in each zone *i* by the number of workers N_i in zone *i* and the average GDP/worker and then summing over all *j* zones:

$$Change\ in\ output\ from\ productivity\ change\ (\Delta GDP_{productivity}) = \sum_j P_i \times N_i \times GDP/worker_i$$

3.2.3 Agglomeration data requirements

Aside from the elasticity of productivity with respect to economic mass (α) (the other data in these calculations will be specific to each of the NeTIRail-INFRA business case studies. The 'local' data required for the calculations include:

- Number of workers in a zone
- Generalised cost of travel between zones by mode and by journey purpose.
- Mode split and journey purpose proportions (business and commuting purposes)
- GDP/worker by zone

It might be the case that data on the number of workers by zone and/or GDP/worker by zone are not available at a sufficiently disaggregate scale. Some modelling assumptions may therefore need to be made. Similarly the results of the agglomeration calculations are sensitive to the treatment of intra-zonal travel costs. It is therefore necessary to estimate these intra-zonal travel costs for inclusion in the agglomeration calculations.

We found that employment data are available for EU countries, but the Turkish employment data is very aggregate making it unlikely that these impacts can be calculated for the Turkish case studies.

3.2.4 NeTIRail-INFRA line types

In principle the agglomeration calculations apply equally across all the NeTIRail-INFRA line types – as all can generate agglomeration economies. From practical purposes however it is likely that only the lines that serve to broaden the effective size of cities will generate agglomeration economies that will have a material relevance to the business case. This would suggest the agglomeration calculations will be most pertinent to the busy commuter line type and less relevant to the low trafficked lines and the freight lines.

Agglomeration benefits are also driven by changes in accessibility – part of which includes fares and part of which includes journey quality (e.g. travel time savings). Where NeTIRail-INFRA lead to only small changes in these journey attributes the agglomeration effects will be small.

3.3 Employment

3.3.1 Summary of employment econometrics

Rail investments can improve accessibility and through that influence labour supply and employment. The framework for this is that better rail connections reduce commuting costs, increasing available employment options such that more workers are willing to work at a given wage, increasing labour supply and employment. The following text is taken from the guidance document TAG Unit A2.1 (DfT, 2014)

"A change in transport costs alters the net financial return to individuals from employment. This is likely to affect the incentives of individuals to work, and therefore the numbers choosing to work and the overall amount of labour supplied in the economy. "

An improvement in rail accessibility will therefore reduce the cost of entering employment through reductions in commuting costs, increasing the options available and the likelihood of finding work.

The literature on employment impacts is far less developed than the other Wider Economic Impacts. Employment impacts can be identified in various ways. One approach (see Sanchez, 1998, Ozbay et al, 2006 and Berechman and Paaswell, 2001, Gibbons et al, 2012, Johnson et al, 2014) is to estimate aggregate local level employment/employment rates as a function of local labour market characteristics and measures of transport accessibility, with variation driven by changes in these variables across time or spatial differences across areas, or through panel data which combines both sources of variation. Another approach is to model individual labour market outcomes (i.e. whether an individual is employed or not) based on a combination of localised factors and personal characteristics (see Rice et al, 2001, Raphael and Rice 1999 for examples). There is no clear identified consensus in terms of transferable evidence of the link between changes in accessibility and changes in employment.

Recent work undertaken by the What Works Centre for Economic Growth (2015) has highlighted the importance of establishing (and the current lack of) a credible evidence base on the linkage between transport and the economy. They found no high quality evaluations on employment effects of rail infrastructure – only evidence of land value effects was found. The study found no high quality evaluations of evidence of the impacts of trams, buses and active modes on any economic outcomes.

The modelling work carried out in these rail investment employment case studies aim to help bridge this evidence gap to further establish the underlying sensitivity of employment to changes in rail accessibility. This is a relatively difficult and unexplored area, characterised by complex modelling and onerous data requirements.

Simple cross sectional analysis of changes in accessibility do not address all the factors driving employment, for example natural resources or the existence of a long-standing employer in an area. The elasticities arising from such models relate to differences in employment between areas rather than changes over time. Also this approach does not deal with the endogeneity of scheme placement, i.e. that transport investments are targeted to address certain policy objectives and do not appear at random.

In order to calculate robust evaluations of the economic impact the case study analysis focuses on differences in before and after employment effects in specific treatment areas and control areas (i.e. the counterfactual). In this way we can identify the existence of an economic impact. The approach here was to identify any economic impacts from these lines, and if identified, consider how to adapt these to the NeTIRaiL-INFRA case studies. The work carried out for these case studies furthers the limited empirical evidence in this field by applying robust estimation methodology to a rich set of data across a range of applications. These approaches are based on household based employment so as such tell us about labour supply responses rather than movement to more productive jobs. We believe that through these case studies we have developed the frontier of knowledge in this area, applying state of the art techniques to identify ex-post impacts of heavy and light rail investments.

3.3.2 Methodology

Differences- in-differences (DiD) method

The differences- in-differences (DiD) method employed in the ex-post case studies exploits the fact that different observations experience differing levels of treatment, with some observations experiencing no treatment. This is an established technique for establishing causal influences of interventions (i.e. rail service enhancements) on outcomes (e.g. employment). This approach uses panel analysis to examine how 'treatment' areas (exposed to the intervention) have performed over time relative to 'control' areas (outside the scope and thus unaffected by the intervention). The panel approach also allows for us to control for time invariant area characteristics that also influence employment.

To implement such an approach we need matching data on the treatment and control groups. Matching data is required for multiple periods (illustrated as time period 1 and 2 below), before and after the treatment.

The DID estimator is derived by taking the difference in outcomes for the treated groups before and after the treatment and comparing with the difference in outcomes for the untreated groups. In this way the DID estimator is purged of any existing difference between treatment groups and any general time period effects.

It can be expressed algebraically in the equation below and with reference to the accompanying Figure 4:

$$y_i = \beta_0 + \beta_1 T + \beta_2 S + \beta_3 (T.S) + \sum_n \delta_n X_{in} + \varepsilon_i$$

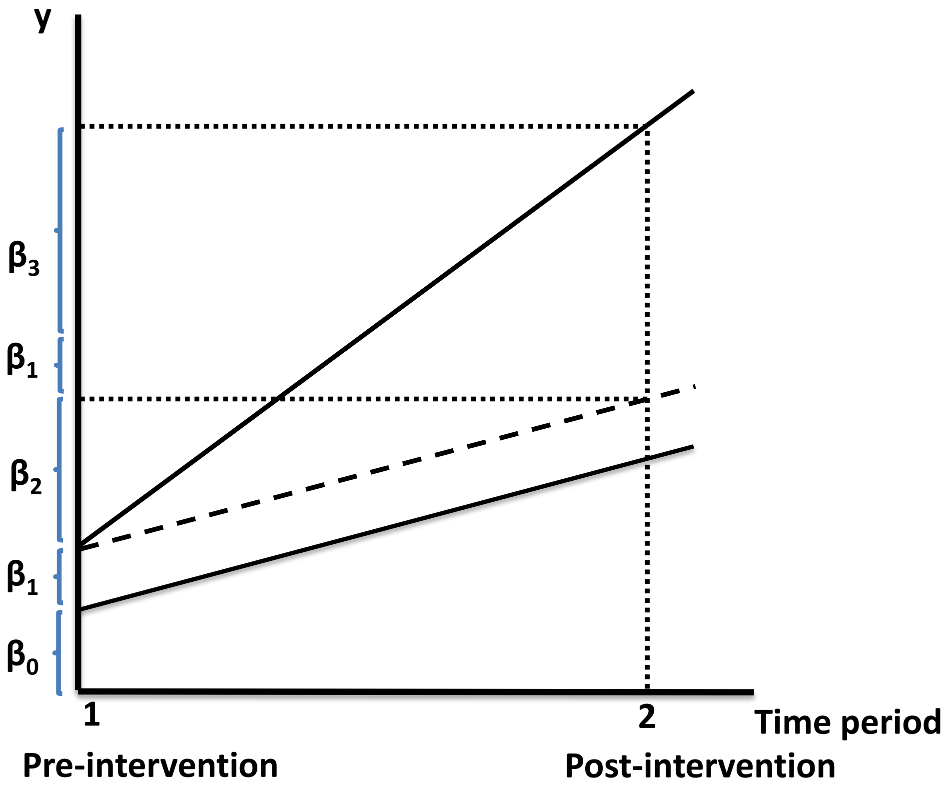
Here y_i represents the employment outcome variable in zone/area *i*, *T* is a dummy variable with a value 1 for the treatment group and 0 for the control, and *S* is the time period dummy which is 1 if time period is 2 (post-intervention). ε_i represents model error. *y* is expressed as a function of an underlying model constant, β_0, the pre-existing difference between the two groups, β_1, the time-related effect, β_2. The treatment effect β_3 is illustrated as the remaining difference after the removal of pre-existing differences and time effects.

Where possible, (*n*) other observable characteristics of areas will be controlled for (the *X*'s) but the remaining difference in economic outcomes between 'treatment' and 'control' areas are considered to be attributable to the changes in rail provision.

In case studies with multiple post-intervention years we capture the treatment effect separately for each year.

Our models are estimated as Fixed Effects (FE) models with the unobserved time invariant characteristics of the data zones captured via a series of constants. The use of FE excludes the explicit use of a treatment area dummy (β_1) as this will be collinear with the data zone constants. Our models thus do not report coefficients on the treatment areas (β_1 as in the equation above).

Figure 4: Difference in Difference parameters



Accessibility Change method

In the case of the rail re-opening case studies of Stirling Alloa and the Robin Hood line we were also able to capture the treatment effect in a more continuous manner by measuring distance to the nearest station from the centre of the area where that distance changes, ie in the treatment areas. This is used as a regressor in place of the *T.S* variable in equation 1.

3.3.3 Case Studies Introduction

Due to the ex-post nature of our work, our employment impacts case study selection necessarily precludes the NeTIRail-INFRA case study lines with their planned innovations. The results from our case studies will help inform the development of the business case for the NeTIRail-INFRA innovations.

Our short list selection criteria as outlined in D1.5 is based on identifying an historic rail investment which:

- Maps onto the case study line types: busy commuter line, low trafficked line and freight line;
- Has existing data that can support an evaluation;
- Has been open sufficiently long for employment impacts to be observed;
- Is ideally situated in the case study countries (Slovenia, Romania and/or Turkey)

Our research indicates that whilst there has been at least one suitable rail investment in Turkey the data available would not support an evaluation of employment impacts. In Romania, whilst we have identified two potentially suitable investments, a closer inspection indicates that the employment impacts are likely to be too small or diffuse to be able to identify in a suitable evaluation study. For Slovenia we identified two potential evaluation studies of which one is too recent and has ongoing construction work associated with a second line. Across our three countries of interest this only left the one potential evaluation study: Murska Sobota – Hodos (Slovenian Hungarian Border).

Given the limited number of potential evaluation studies we broadened our scope to include potential investments from Sweden and the UK for which data suitable for an evaluation exists. D1.5 explained the other investments are either too recent or the employment impacts are likely to be too small to identify.

This short listing procedure therefore gives rise to a short list of seven potential evaluation studies as shown in Table 2. Three of these short listed investments were Swedish, none of which were taken forward. This is because a more detailed investigation of the smallest areas for which the economic data were available were large in relation to the location of the stations/freight terminals of the railways affected. Simple regression analysis, which is not reported here, was also undertaken for one of the lines which unfortunately confirmed this assessment, indicating that there would be too many confounding effects. We therefore retained Murska Sobota – Hodos (Slovenia) and the three UK rail investments (Mansfield to Nottingham 'Robin Hood Line', Manchester metro and Stirling-Alloa). Whilst all four historic investments are covered here, we have only estimated full econometric models on the UK based case studies following a detailed consideration of the data available and the accessibility and economic changes observed.

Table 2: Rail Investment Case Study Shortlist

NeTIRail-INFRA Line Type	Rail investment project	Case study analysis
Busy commuter line	Murska Sobota – Hodos (Slovenia) Mansfield to Nottingham (UK) Manchester metro (UK) Svealandsbanan (Sweden)	Descriptive Full Full No
Low Trafficked line	Stirling- Alloa (UK) Blekinge kustbaba (Sweden)	Full No
Freight	Haparandabana (Sweden))	No

Unfortunately, we were unable to find an historic rail freight investment that was able to provide sufficient quality data that would permit econometric investigation within the scope of this study.

3.3.4 Stirling Alloa (UK)

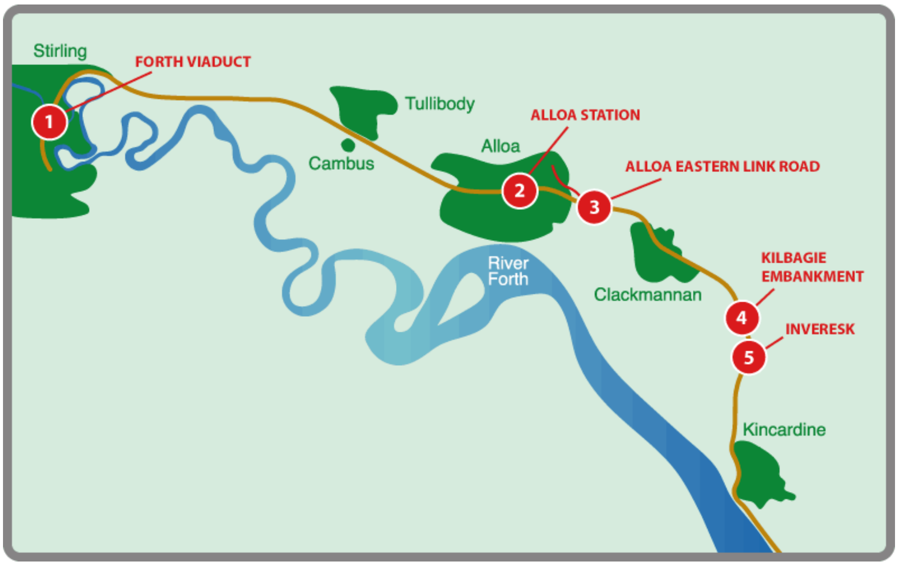
Introduction

The new rail link between Stirling and Alloa has been selected as a case study of a low trafficked line.

The Stirling-Alloa project (see Figure 5) involved re-opening a 21km long existing, disused railway line between Stirling Station and Longannet Power Station in Kincardine which closed in 1968. The line was re-commissioned in March 2008 for both passenger and freight services.

The line reconnects Alloa to Stirling and then on to Glasgow and Edinburgh to rail traffic. It affords no significant additional urban quality improvements, but has noticeably improved public transport accessibility to Glasgow and Edinburgh for commuting and shopping purposes, and hence meets the criteria of the study. The study covers the period 2001 to 2011 which spans the rail intervention, allowing for "before" and after" comparisons to be made. Underlying data sources have exhibited heterogeneous statistical properties, particularly in terms of geographical coverage and the representation of dwelling types.

Figure 5- Schematic map of Stirling Alloa line extension

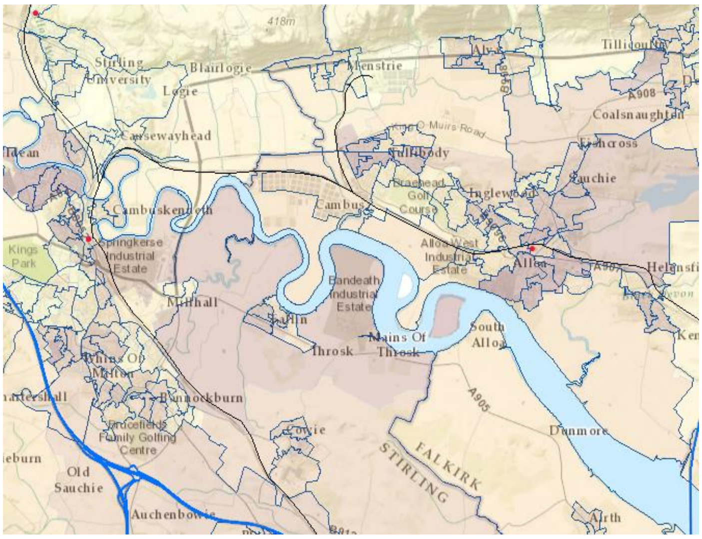


Source: Railfuture Scotland Conference 2012: Report on the Stirling Alloa Line

Alloa Station is now connected to the national rail network for the first time in 50 years. The new line operates an hourly direct passenger service between Alloa, Stirling and Glasgow Queen Street stations, also allowing passengers to change at Stirling for further travel to Edinburgh Waverley Station.

The map below in Figure 6 shows the area around the rail link between Stirling and Alloa. The river Forth winds its way through the region, and there is no bridge between Stirling and Kincardine. The Ochil Hills to the north of the A91 Stirling to St. Andrews road rise to more than 2000 feet and form a major barrier to the North.

Figure 6- Stirling – Alloa line and surrounding area.

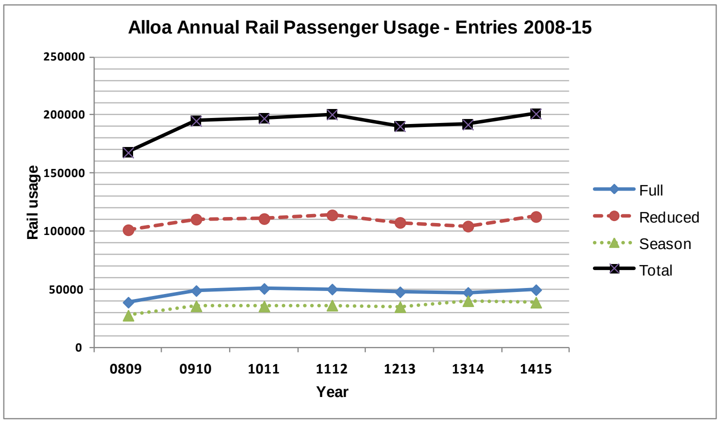


Source: Map produced using ARCGIS layered from a combination of Scottish data zones boundary data, and deprivation levels based on SIMD (Scottish Index of Multiple Deprivation) 2012.

Current impact of the rail intervention

It is useful to identify, if possible, that the re-opening of the line has led to more rail usage in the area. Since the opening of the line to Alloa, as shown in Figure 7, season ticket usage has climbed steadily to 21% suggesting an increase in commuting. The high number of reduced fares hinting that those with concessionary status prefer rail travel to other forms of public transport.

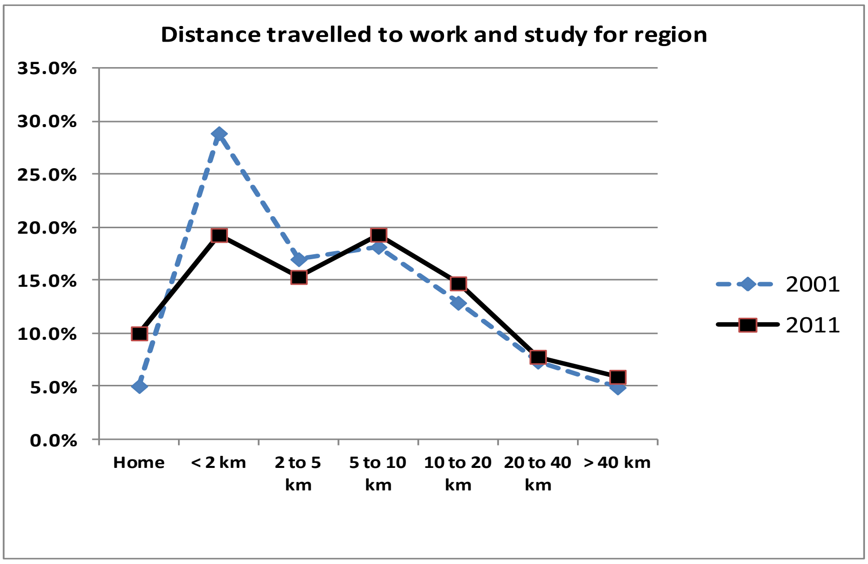
Figure 7: Alloa station usage



Source: ORR Office of Road and Rail Regulation Portal, http://orr.gov.uk/statistics/published-stats/station-usage-estimates

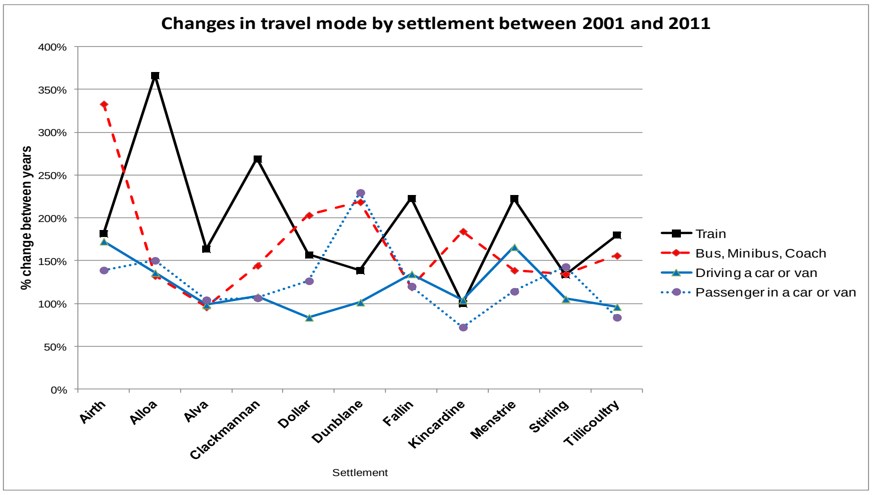
The distance travelled to work figures (Figure 8) indicate a change between 2001 and 2011 with more people travelling further than 2.5 km. This is more marked in Alloa and Clackmannan which are closest to the rail link but also apparent in areas further away. Dunblane showed very little change over the same period. Figure 9 shows there has also been a noticeable change in travel mode between the 2001 and 2011 censuses which span the rail intervention. Only Dunblane has experienced no change in distance to a station over that period.

Figure 8: Distance travelled to work



Source: 2001 and 2011 census

Figure 9: Changes in travel mode by settlement.



Source : 2001 and 2011 UK Census ONS Office for National Statistics

Data

We have constructed a database comprising both economic and rail-related data based on UK census data from 2001 and 2011 with data at the Scottish data zone level.

Figure 6 shows the boundaries based on Scottish data zones of which there are approximately 7000, (with shaded areas representing deprivation levels based on SIMD (Scottish Index of Multiple Deprivation) 2012. These data zones typically accommodate the standard population size of between 500-1000. As is the case with many data zones in remote areas, these can cover an expansive area and be very sparsely populated. Table 3 shows the variables as used in our models.

Table 3: Stirling Alloa variable definitions

Variable name	*Definition*
LnEmp	Log of Employment *(Dependent variable)*
NCA	Proportion of households with no car availability
Pop1864	Population age 18-64
LnPop	Log of population age 18-64
BusinessFinance	Proportion of employment in Business/Finance sectors
Retail	Proportion of employment in Retail/Hospitality sectors
Public	Proportion of employment in Public sectors
Other	Proportion of employment in Other sectors
Base group MC	*Proportion of employment in manufacturing and construction sectors*
Lev4	Proportion of adult population with level 4 qualifications (degree level) or above
treat2011	Treatment area (1 if treatment, 0 if control)
Lndist_treatment	Log of distance to nearest station in treatment areas
Year2011	Dummy for year (1 if 2011, 0 if 2001)

Treatment and control areas

By examining 2km contours radiating from Alloa station, we used data on the change in house price against distance from the station served to assign control and treatment groups. The period 2005 to 2011 showed an uplift in prices within 6 km of the station in the aftermath of the rail intervention. This suggested that the treatment group should embrace those areas within 6km of Alloa station experiencing a reduction in distance with the opening of the new link.

The treatment group included 59 data zones within 6km around Alloa and adjacent towns such as Tullibody and Clackmannan where some impact could be expected.

The control groups included 20 data zones around Dollar and Kincardine where preliminary data analysis on house price impacts had shown little impact. These towns had the advantage for comparison purposes of being within the same geographical region and with a similar economy, however they may still be affected due to ‘spill over’ effects from the intervention.

Descriptive statistics for the treatment and control areas are shown in Table 4.

Table 4: Stirling Alloa descriptive statistics

		Control areas					
		Year 2001			Year 2011		
Variable	Obs	Mean	Min	Max	Mean	Min	Max
NCA	20	0.16	0.03	0.33	0.14	0.04	0.27
Pop1864	20	564.05	371.00	666.00	573.55	384.00	1159.00
LnPop	20	6.32	5.92	6.50	6.32	5.95	7.06
EmpRate	20	0.92	0.84	0.96	0.91	0.85	0.95
EmpNum	20	348.35	229.00	437.00	353.20	226.00	808.00
LnEmp	20	5.84	5.43	6.08	5.83	5.42	6.69
MC	20	0.17	0.10	0.28	0.15	0.11	0.20
BusinessFinance	20	0.19	0.12	0.28	0.06	0.02	0.11
Retail	20	0.22	0.17	0.29	0.21	0.15	0.26
Public	20	0.31	0.21	0.39	0.39	0.29	0.46
Other	20	0.10	0.05	0.19	0.20	0.13	0.30
Lev4	20	0.36	0.12	0.53	0.43	0.15	0.60
Treatment	20	0	0	0	0	0	0
treat2011	20	0	0	0	0	0	0
year2011	20	0	0	0	1	1	1

		Treatment areas					
		Year 2001			Year 2011		
Variable	Obs	Mean	Min	Max	Mean	Min	Max
NCA	59	0.30	0.02	0.58	0.26	0.02	0.56
Pop1864	59	548.93	365.00	1236.00	614.02	369.00	2407.00
LnPop	59	6.28	5.90	7.12	6.36	5.91	7.79
EmpRate	59	0.89	0.76	0.95	0.87	0.72	0.94
EmpNum	59	307.80	177.00	498.00	363.83	193.00	1309.00
LnEmp	59	5.70	5.18	6.21	5.83	5.26	7.18
MC	59	0.26	0.15	0.34	0.21	0.15	0.27
BusinessFinance	59	0.13	0.07	0.19	0.04	0.01	0.07
Retail	59	0.27	0.20	0.37	0.27	0.19	0.43
Public	59	0.27	0.15	0.37	0.35	0.23	0.45
Other	59	0.08	0.05	0.13	0.12	0.08	0.18
Lev4	59	0.13	0.03	0.32	0.19	0.08	0.37
Treatment	59	1	1	1	1	1	1
treat2011	59	0	0	0	1	1	1
year2011	59	0	0	0	1	1	1
Dist_treatment	59	9.15	5.69	13.09	2.76	0.38	5.61

Results

Table 5: Stirling Alloa line results

LnEmp	*Coef.*	*t*	*Coef.*	*t*
NCA	-0.997	-5.84	-1.043	-6.42
LnPop	1.066	21.74	1.046	22.53
BusinessFinance	0.019	0.06	-0.071	-0.22
Retail	-0.199	-0.82	-0.336	-1.43
Public	0.189	0.73	0.077	0.31
Other	-0.301	-0.92	-0.234	-0.76
Lev4	0.305	1.08	0.478	1.75
year2011	-0.031	-0.69	-0.060	-1.65
treat2011	0.018	0.53		
Lndist_treatment			-0.027	-2.96
_constant	-0.769	-2.18	-0.528	-2.14
Obs	158		158	
Groups	79		79	
R-squared overall	0.8816		0.8831	

We present 2 models in **Table** 5; one using the difference in difference methodology, with the treatment impacts identified 2011, and in the final two columns we present the results where we use the distance from the nearest rail station where distance changes, to capture the treatment effect.

Both models report the impacts on employment of local demographic characteristics as statistically significant (absolute value of t-statistic >1.96) and with expected sign. Population is a key driver of absolute level of employment. We also find significant impacts for Non-Car availability; lower levels are often an indication of deprivation. We found no significant impacts of industrial structure as captured by the proportions of workers in the Business/Finance, Retail, Public and Other sectors as compared to the base group of Manufacturing/Construction. There were also no significant impacts on employment for areas with higher levels of degree level attainment.

Treat2011 is the treatment indicator in the first model. Here we see a positive but insignificant impact on employment in treatment areas in 2011 compared to 2001.

Lndist_treatment reports the impact on employment of the change in access distance to the nearest station in the treatment areas. We find this to be significantly negative; ie the impact of a reduction in distance to the nearest rail service in the treatment areas is associated with higher employment levels. This requires a little interpretation best illustrated through an example: If distance to the nearest station in a treatment area had fallen from 10km to 9km *(a 10% fall)*, from the coefficient of -0.027 we would see an increase in employment of around 0.27% in this area from the improvement in accessibility.

Given the nature of the line, many of the extra trips would be for shopping or accessing services in Stirling. Whilst serving an important purpose in improving connectivity of Alloa, the social benefits might not be best captured through measures of employment change.

3.3.5 Manchester Metrolink (UK)

Introduction

The early phases of the Metrolink light rail link in Manchester have been selected as a case study of a busy commuter line.

Phase 1 is a 31.5 km stretch of line, opened on April 1992 and linking Altrincham in the south-west and Bury in the north via Manchester city centre, using former heavy rail alignments. The heavy rail did not cross the city centre and had to stop in the northern station of Manchester Victoria and the Southern station, Manchester Oxford Road. Phase 1 connected the two alignments with on street running through the city centre, giving a continuous north/ south connection and more convenient interchanges with the heavy rail systems.. The scheme also aimed to reduce traffic congestion by providing modern, attractive public transport options for journeys into the city centre.

The re-opened line also featured infrastructure enhancements including:

- Refurbished stations featuring better access, lighting and information systems and ticket machines.
- A new underpass was built at the former Cornbrook Junction to avoid using the busy Warrington Liverpool line into the centre.

When Metrolink opened, a 12-minute frequency was provided between Altrincham and Piccadilly, enhanced at peak hours by a second 12-minute frequency from Altrincham to Bury via Manchester city centre. A 6-minute frequency was introduced and later extended to operate all day Monday to Saturday, with trams alternating to Piccadilly and Bury.

Phase 2 is a shorter line with a length of 6.4km opened on December 1999 between Eccles and Manchester city centre via Salford Quays, previously an area that suffered economically following the closure of Manchester Docks. This was a new line, introduced alongside the redevelopment of the area.

Data

In order to be able to measure the impact of the light rail corridor in Greater Manchester on the employment growth in these areas, we have constructed a database comprising both economic and LRT-related data based on UK census data from 1991, 2001 and 2011[2]. The study area has used the data from different boroughs: Bolton, Bury, Rochdale, Oldham, Tameside, Stockport, Manchester, Trafford and Salford.

The geography of the census consists of a hierarchical subdivision of UK local government areas of various types down to sub-authority areas, such as wards, to lower levels created specifically for census purposes. We use the lowest available level of aggregation in the published census data. In 2001 and 2011 we used the Lower Super Output Area-lower layer classification. Lower layer super output areas (LSOAs) have a minimum size of 1,000 residents and 400 households, but average 1,500 residents.

In 1991 the aggregation level was Enumeration district. The UK was divided into around 130,000 *Enumeration Districts.* In England and Wales an average enumeration district (ED) comprised about 200 households, containing about 400 persons. In Scotland EDs were, on average slightly smaller.

[2] Downloaded from https://www.nomisweb.co.uk/

To be able to apply consistent geography in our database, we use an application that convert the data from one database (1991 & 2001) to other (2011). GeoConvert[3] is an online geography matching and conversion tool for use by staff and students in UK Higher and Further Education. It allows users to obtain and manipulate complex geographical in easy way in a straightforward way. The final database for estimation consists of a panel of observations at the Lower Super Output Area (LSOA) level for the Greater Manchester area for the years 1991, 2001 and 2011.

Treatment and control areas

The problem of isolating the treatment effect produced by any policy (in this case, the introduction of light rail) has been solved by comparing areas that have been influenced in the light rail corridors with control areas which have similar characteristics. These controls represent what would have occurred in the light rail corridors if the light rail schemes had not been built. These areas should be comparable with the light rail corridors, but should not have been invested in light rail.

We use treatment and control areas based on the wards based on Lee and Senior (2013)[4] and illustrated in Figure 10. They identified control areas by comparing each light rail corridor's profile of worker household car ownership and rail use in 1991 with values of the same variables for potential control area wards. They identified a final set of control area wards for both light rail corridors with similar car ownership and rail use in 1991, and a similar range of distances from the relevant city centre. As Phase 2 provides a new alignment in a corridor where there were few rail journeys, the control area for Phase 2 had very low rail shares too. City centre areas served by light rail (in 2001) were excluded from these corridors associated control areas could not be identified.

[3] http://geoconvert.mimas.ac.uk/

[4] Wards are a higher level of disaggregation so we identified the LSOAs within each of the wards using GIS software.

Variables in Estimation

The set of final variables used in estimation of our models are shown in Table 6. We are using 3 years of data, so we identify a separate treatment effect for Phase 1 in 2001 (t2001treat1) and 2011 (t2011treat1) as compared to 1991, before opening. For Phase 2 we identify 1 treatment effect (t2011treat2) as there is only 1 post opening census wave. Separate descriptive statistics for these areas for each phase are shown in Table 7 and Table 8.

Table 6: Metrolink Variable definitions

Variable	*Description*
employed	Number of people employed
lnemployed	Log of Employment *(dependent variable)*
NCA	Proportion of households with no car availability
Pop	Population age 18-64
lnpop	Log of population age 18-64
Popdens	Population density (population per hectare)
lev4quals	Proportion of adult population with level 4 qualifications (degree level) or above
non_white_proportion	Proportion of non-white population
manuf	*Proportion of employment in manufacturing and construction sectors*
retail	Proportion of employment in Retail/Hospitality sectors
transport	Proportion of employment in transport/communications/warehousing sectors
business	Proportion of employment in Business/Finance sectors
public	Proportion of employment in Public sectors
other	Proportion of employment in Other sectors
t2001treat1	Treatment area for phase 1 in 2001 (1 if phase1 in 2001, 0 otherwise)
t2011treat1	Treatment area for phase 1 in 2011 (1 if phase1 in 2011, 0 otherwise)
t2011treat2	Treatment area for phase 2 in 2011 (1 if phase1 in 2011, 0 otherwise)

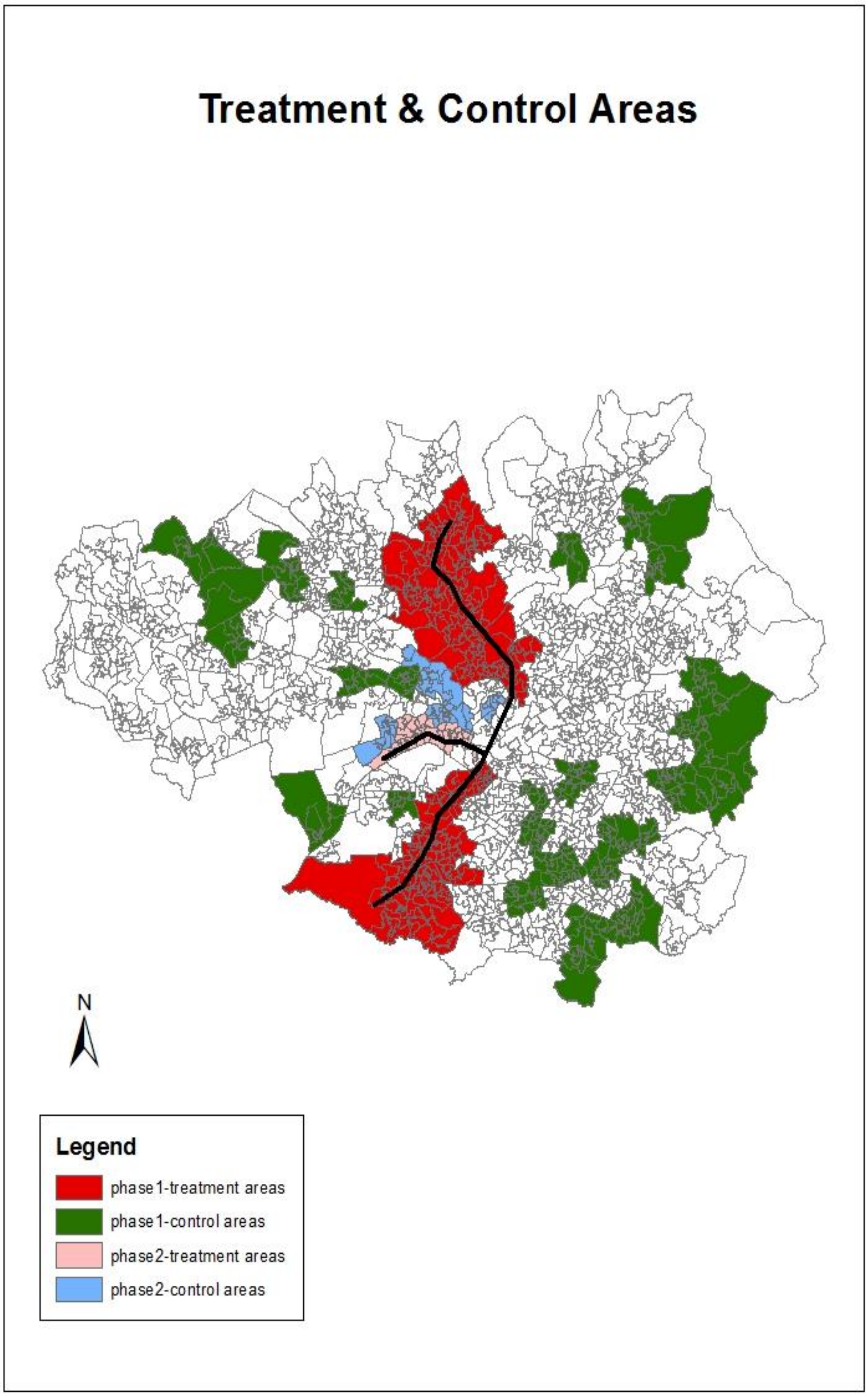
Table 7: Metrolink Phase 1 treatment and control areas

	Phase 1							
		Control			Treatment Area			
		1991	2001	2011		1991	2001	2011
Variable	Obs	Mean	Mean	Mean	Obs	Mean	Mean	Mean
NCA	257	0.35	0.29	0.27	224	0.33	0.27	0.24
Pop	257	1496.51	1513.96	1607.32	224	1508.11	1508.35	1625.19
lnpop	257	7.30	7.32	7.37	224	7.31	7.32	7.38
Popdens	257	36.59	37.54	40.26	224	39.97	39.75	42.89
lev4quals	257	0.14	0.19	0.25	224	0.15	0.21	0.30
employed	257	656.79	652.72	700.28	224	663.09	659.96	738.39
lnemployed	257	6.46	6.45	6.53	224	6.48	6.47	6.59
prop_employed	257	0.89	0.90	0.87	224	0.90	0.92	0.89
non_white_proportion	257	0.05	0.07	0.13	224	0.06	0.10	0.17
manuf	257	0.28	0.23	0.17	224	0.25	0.20	0.14
retail	257	0.22	0.23	0.23	224	0.21	0.22	0.22
transport	257	0.06	0.07	0.05	224	0.06	0.08	0.05
business	257	0.11	0.16	0.20	224	0.14	0.19	0.24
public	257	0.27	0.25	0.29	224	0.28	0.25	0.29
other	257	0.06	0.06	0.06	224	0.06	0.06	0.06

Table 8: Metrolink Phase 2 treatment and control areas

	Phase 2							
		Control			Treatment Area 1			
		1991	2001	2011		1991	2001	2011
Variable	Obs	Mean	Mean	Mean	Obs	Mean	Mean	Mean
NCA	38	0.50	0.43	0.40	27	0.54	0.46	0.43
Pop	38	1533.29	1448.34	1558.58	27	1625.43	1474.04	1564.37
lnpop	38	7.31	7.28	7.34	27	7.38	7.29	7.35
Popdens	38	49.85	47.06	49.81	27	53.30	46.81	48.64
lev4quals	38	0.06	0.12	0.17	27	0.08	0.14	0.21
employed	38	562.30	533.16	624.45	27	613.30	572.33	680.96
lnemployed	38	6.31	6.25	6.41	27	6.40	6.33	6.50
prop_employed	38	0.83	0.87	0.84	27	0.84	0.89	0.85
non_white_proportion	38	0.02	0.05	0.10	27	0.03	0.05	0.12
manuf	38	0.25	0.21	0.15	27	0.26	0.21	0.14
retail	38	0.22	0.24	0.25	27	0.24	0.24	0.25
transport	38	0.07	0.08	0.06	27	0.06	0.08	0.06
business	38	0.10	0.16	0.19	27	0.11	0.17	0.21
public	38	0.29	0.25	0.29	27	0.28	0.24	0.28
other	38	0.07	0.06	0.06	27	0.04	0.06	0.06

Figure 10: Metrolink Treatment and Control Areas



Results

Table 9: Manchester Metrolink line results

	Fixed effects	
LnEmp	Coef.	t-stat
t2001treat1	0.0116	1.42
t2011treat1	0.0194	1.18
t2011treat2	0.0768	5.00
logpop	0.886	20.70
Lev4quals	0.425	5.08
Popdens		
NCA	-1.129	-15.70
manuf	-0.0269	-0.31
public	0.0679	0.74
business	0.0574	0.57
retail	-0.375	-2.47
Year2001	-0.115	-12.67
Year2011	-0.137	-9.61
_cons	0.395	1.15
Obs	1638	
Groups	546	
R-squared overall	0.6112	

Table 9 shows the results of the Fixed Effects model estimation. As expected there are significant (ie absolute t-value of >1.96) impacts of overall population and car ownership changes over time. Higher concentrations of employment in retail are associated with lower overall levels of employment. *Year2001* and *2011* control for negative macroeconomic effects on employment compared to 1991. Our results suggest no significant impact of line 1 on employment in either post-intervention period (*t2001treat1* and *2011treat1*), but a significantly positive association in line 2 as captured by the coefficient on *t2011treat2*. The parameter of 0.077 on *t2011treat2* indicates that the new line is associated with an increase in employment of about 7.7% in the treatment areas, all else equal.

The new rail service in Phase 2 formed part of a package of re-development initiatives in the area of East Manchester. Whilst we have used control areas within the re-development area it may be that the observed employment effects may not be exclusively attributable to the line itself.

3.3.6 Robin Hood Line – Mansfield to Nottingham (UK)

The Robin Hood Line is a 'busy commuter' railway line running from Nottingham to Worksop via Mansfield (see Figure 11), in Nottinghamshire but also straddling parts of Derbyshire between Shirebrook and Whitwell. It has been fully open to Worksop since 1998. The area is dominated by Mansfield as the main central town and its links to Nottingham in the south and Sheffield to the north. Mansfield is connected by rail to Nottingham and Worksop (and onward to Sheffield), as shown in Figure 12. Prior to the re-opening of the line, Mansfield was one of the largest towns in Britain without a railway station from when the line was closed following the Beeching cuts of the 1960s.

The line is operated by East Midlands trains and runs half hourly services between Nottingham and Mansfield, with one service per hour continuing to Worksop, with a total journey time of 67 minutes. As such this case study represents a well-used commuter line.

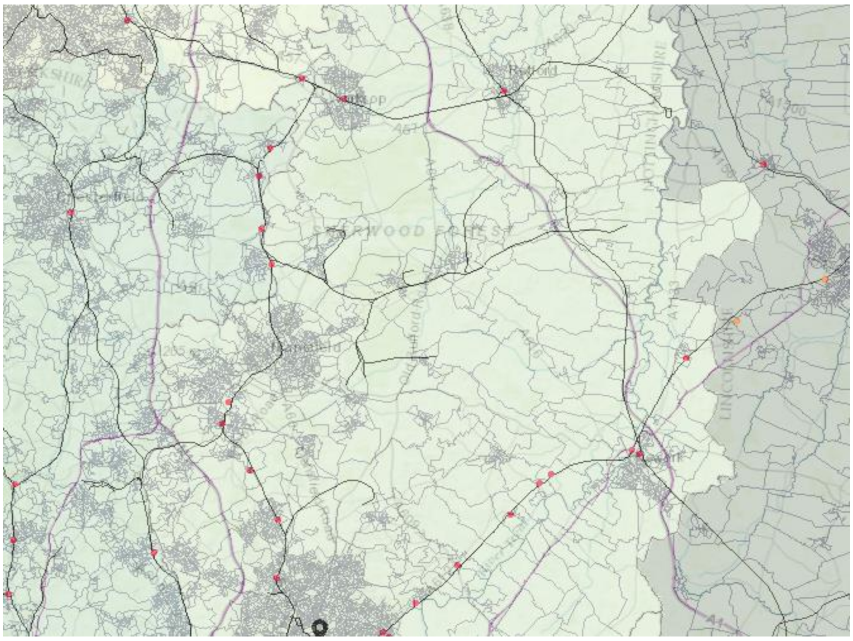
Figure 11: Robin Hood line stations

Robin Hood Line is a larger scale and differs principally from the Stirling-Alloa case study for the following reasons:

- The intervention has been in place much longer (approx 20 years)
- There are 10 new rail stations available following the intervention
- There is a wider range of stations further away that have always been available

- LSOA (equivalent to data zones in Scotland) populations much larger but areas generally smaller
- Nottingham is a much larger conurbation and now includes a tramway system
- Motorway links are much nearer in some cases

Figure 12: Robin Hood line map



Data

As with the other UK case studies we have constructed a database comprising both economic and rail-related data based on UK census data at the lowest available level of aggregation; this time from 1991, 2001 and 2011[5]. The study area has used the LSOA data from different areas around Mansfield, North Nottingham and Worksop. LSOA is the lowest available level of aggregation in the published census data, converted to consistent geography using the GeoConvert tool.

[5] Downloaded from https://www.nomisweb.co.uk/

This database consists of statistics on demography, economy and environment by LSOA for the 3 census years with the precise definitions shown in Table 10.

Table 10: Robin Hood line variable definitions

Variable	*Description*
Pop	Population 18-64
lnEmp	Log number people employed *(dependent variable)*
employed	Number of people employed
NCA	Proportion of households with no car availability
Man_Con	*Proportion of employment in manufacturing and construction sectors*
Ret_Hot_Cat	Proportion of employment in Retail/Hospitality sectors
Prof	Proportion of employment in Professional/Business/Finance sectors
Density	Population density (population per hectare)
Lev4	Proportion of adult population with level 4 qualifications (degree level) or above
treat	Treatment area (1 if treatment, 0 if control)
Disttreat	Distance to nearest station in treatment areas
Disttreat2011	Distance to nearest station in treatment areas in 2011; 0 otherwise
Year2001	Dummy for year (1 if 2001, 0 otherwise)
Year2011	Dummy for year (1 if 2011, 0 otherwise)
Treat2001	Dummy for treatment (1 if treatment area in 2001, 0 otherwise)
Treat2011	Dummy for treatment (1 if treatment area in 2011, 0 otherwise)

Treatment and control areas

The case study area was created based on selecting the districts below and then breaking them down further into LSOA Codes. The districts chosen all bordered on or included the Robin Hood Line from Worksop to Nottingham and included:

- Amber Valley
- Ashfield
- Bassetlaw
- Bolsover
- Broxtowe
- Chesterfield
- Derby
- Derbyshire Dales
- Erewash
- Gedling
- Mansfield
- Newark and Sherwood
- North East Derbyshire
- North West Leicestershire
- Nottingham
- Rushcliffe
- South Derbyshire

These areas are either adjacent to the line or in the same region and therefore similar in profile to those near the line. Each district is not always represented fully.

Within these areas we provisionally designated LSOA level treatment areas as those areas where distances to the nearest station actually changed. Control areas were unaffected by the new line. However, some of these areas were very far from a rail station (eg over 15km); further away than the treatment areas were from stations before the re-opening, so these were rendered out of scope. Additionally we found that control areas had higher average levels of qualifications and car availability so we removed some of the higher incidences of these from our control data set. In this way we arrived at a profile of treatment and control areas which were comparable in terms of distance from stations, car availability and higher qualifications.

Descriptive statistics for the treatment and control and treatment areas are shown in Table 11 and

Table 12 respectively.

Table 11: Robin Hood Line control areas descriptive statistics

treat	0,	DataYear	1991		DataYear	2001		DataYear	2011	
Variable	Obs	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Pop	126	1204.50	573.00	1892.00	1084.83	757.00	1610.00	1151.07	807.00	1877.00
lnEmp	126	6.46	5.77	6.98	6.47	5.80	6.94	6.56	6.04	7.05
emp_prop	126	0.89	0.68	0.96	0.92	0.79	0.96	0.90	0.78	0.95
employed	126	653.49	320.00	1072.00	659.90	330.00	1034.00	717.60	419.00	1158.00
NCA	126	0.31	0.09	0.67	0.25	0.06	0.63	0.22	0.03	0.52
Man_Con	126	0.38	0.16	0.58	0.34	0.14	0.47	0.27	0.11	0.35
Ret_Hot_Cat	126	0.18	0.04	0.34	0.21	0.16	0.30	0.22	0.14	0.31
Prof	126	0.07	0.00	0.16	0.11	0.06	0.22	0.03	0.01	0.06
Density	126	21.17	0.41	69.07	21.81	0.46	64.81	22.35	0.49	71.37
Lev4	126	0.09	0.00	0.25	0.12	0.03	0.32	0.19	0.07	0.41
treat	126	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LSOAnum	126	193.08	1.00	472.00	193.08	1.00	472.00	193.08	1.00	472.00
lnPop	126	7.08	6.35	7.55	6.98	6.63	7.38	7.03	6.69	7.54

Table 12: Robin Hood Line treatment areas descriptive statistics

treat	1,	DataYear	1991		DataYear	2001		DataYear	2011	
Variable	Obs	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Pop	293	1198.65	528.00	1892.00	1084.50	617.00	1614.00	1159.52	662.00	1921.00
lnEmp	293	6.42	5.54	6.92	6.41	5.60	6.92	6.53	5.73	7.19
emp_prop	293	0.87	0.69	0.96	0.90	0.77	0.96	0.89	0.70	0.95
employed	293	627.95	254.00	1015.00	625.63	271.00	1017.00	701.94	308.00	1322.00
NCA	293	0.34	0.04	0.69	0.29	0.04	0.68	0.26	0.05	0.71
Man_Con	293	0.32	0.10	0.62	0.28	0.12	0.49	0.21	0.11	0.33
Ret_Hot_Cat	293	0.21	0.05	0.42	0.23	0.16	0.31	0.24	0.14	0.34
Prof	293	0.07	0.00	0.22	0.11	0.06	0.22	0.03	0.00	0.08
Density	293	28.20	0.22	105.03	29.06	0.23	99.87	29.79	0.22	103.07
Lev4	293	0.08	0.00	0.30	0.12	0.03	0.44	0.18	0.05	0.49
treat	293	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
LSOAnum	293	258.21	2.00	473.00	258.21	2.00	473.00	258.21	2.00	473.00
lnPop	293	7.07	6.27	7.55	6.98	6.42	7.39	7.04	6.50	7.56
disttreat	293	8.92	2.21	16.75	3.11	0.27	13.99	3.11	0.27	13.99

Results

We present 2 models in

Table 13; one using the difference in difference methodology, with the treatment impacts identified separately for 2001 and 2011 and in the final two columns we present the results where we use the distance from the nearest rail station to capture the treatment effect.

Both models report the impacts on employment of local demographic characteristics as significant (ie absolute t-value of >1.96) and with expected sign. As expected, population is a key driver of absolute level of employment. We also find significant impacts for Non-Car availability; lower levels are often an indication of deprivation. We found increasing levels of employment in areas which had seen higher concentrations of professional industries (eg banking, finance, IT). Population density also had a positive impact on employment. Areas with higher levels of degree level attainment also had higher levels of employment.

We use the *year2001* and *year2011* variables to control for macro-economic factors.

treat2001 and *treat2011* are the treatment indicators in the first model. Here we actually see a negative impact on employment in treatment areas in 2011 compared to 1991, but insignificant when comparing 2011 to 1991.

Lndisttreat reports the impact on employment of the distance to the nearest station in the treatment areas. We also interact this with 2011 to derive *Lndisttreat2011* to inspect whether there are any additional impacts on employment in 2011 over and above those in 2001. We find *Lndisttreat* to be actually significantly negative for, suggesting that areas which had seen a reduction in distance to the nearest station experienced a positive employment impact. This requires a little interpretation best illustrated through an example: If distance to the nearest station in a treatment area had fallen from 10km to 9km *(a 10% fall)*, from the coefficient of -0.00765 we would see an increase in employment of around 0.08% from this improvement in accessibility. *Lndisttreat2011* is insignificant.

Table 13: Robin Hood Line model results

	Treatment model		*Distance Model*	
lnEmp	Coef.	T-Stat	Coef.	T-Stat
NCA	-1.194	-18.73	-1.199	-20.98
Man_Con	0.0751	1.76	0.0739	1.69
Ret_Hot_Cat	0.0634	1.05	0.0540	0.91
Prof	0.181	1.73	0.151	1.69
Density	0.00305	2.24	0.00304	3.4
Lev4	0.232	2.62	0.230	3.14
lnPop	0.917	28.58	0.918	36.07
Lndisttreat			-0.00765	-2.21
Lndisttreat2011			-0.00245	-0.56
treat2001	-0.0150	-2.19		
treat2011	0.00924	1.03		
year2001	0.0174	2.19	0.0015	0.18
year2011	0.0145	1.01	0.0144	1.21
_cons	0.188	0.92	0.2039	1.19
R-Squared		0.8452		0.8469
obs		1257		1257
groups		419		419

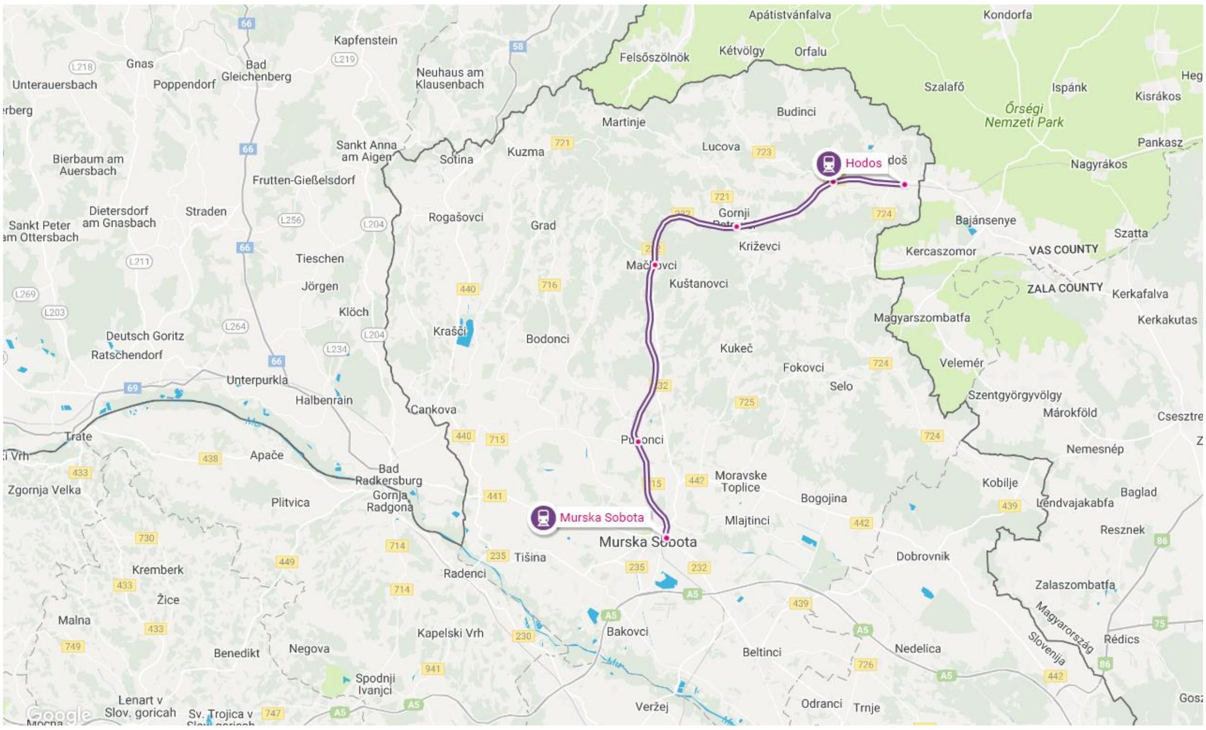
3.3.7 Murska Sobota – Hodos (Slovenia)

Introduction

This is a new line 30km ‘busy commuter’ between Murska Sobota and the Slovenian/Hungarian border, with Hodos as a common border station, and has been completed and in operation since Spring 2001. It cost €97 million and is part of the TEN-T corridor V. The route on the Slovene side runs from Puconci via Hodos to the state border. The first stage non-electrified single-track route for goods and passenger transport enables speeds of up to 160 kilometres per hour. The route carries freight (now being the shortest link between North-Adriatic ports and countries in Central and Eastern Europe), international services from Ljubljana and more local stopping services. As such, it is not neatly categorised into a single NeTIRail-INFRA line type. Figure 13 shows the line on a map of the Mura region and

Figure 14 shows the line within the context of the overall Slovenian rail network.

Figure 13: Murska Sobota to Hodos rail extension



Source: https://www.rome2rio.com/s/Murska-Sobota/Hodo%C5%A1

Figure 14: Slovenian Rail network

Source: http://www.slo-zeleznice.si/en/passenger-transport/timetable/network-map

Data

The Republic of Slovenia Statistical Office hosts detailed macroeconomic time series data. The SI-Stat Data Portal allows interrogation of statistics on demography, economy and environment by geographical area and year.

- Labour Market including employment and activity
- Demography
- Population
- Educational attainment
- Road vehicles
- Geography

These are available at the municipality and statistical region level

Slovenia is divided into 12 statistical regions (NUTS3) and 212 municipalities within these regions with consistent data series on population, employment going back to at least year 2000. We focused our analysis within the Mura statistical region where the new line is situated. This the most north easterly region, bordering on Hungary, Austria and Croatia. Within this region there are 27 municpalities which form the basis of our dataset. We used google maps to identify which of these municipalities would have seen an improvement in rail accessibility, assuming that if the main settlement in each municipality was more than 10km from a station on the line it would not be impacted (a control area) and if less than 10km from a station we designated this a treatment area, benefiting from improved rail accessibility.

Results

We conducted provisional difference in difference analysis (without any other controls) based on population weighted employment rates (proportion of economically active people in work) within our treatment and control areas for the period 2002-2015. The results in

Table 14 show that within the treatment areas, employment fell by approximately 2 percentage points from 84.4 to 82.5% whereas in the control areas, the rate fell less (81.3 to 80.8%). This suggests no evidence of an economic effect of the line. That is not to say there wouldn't have been an economic impact – an international trade improvement stemming from the inter city services and freight services to the Hungarian border may have brought economic benefits but these may be spread over a further catchment area and thus more difficult to detect.

Table 14: Difference in Difference analysis for Murska Sobota-Hodos line.

Municipalities	2002		2015		
Treatment Areas	Emp Rate	Population 15-64	Emp Rate	Population 15-64	Change in Emp Rate
Beltinci	0.863	5970	0.810	5661	-0.052
Gornji Petrovci	0.841	1543	0.834	1380	-0.007
Hodoš/Hodos	0.830	226	0.805	226	-0.026
Ljutomer	0.833	8538	0.848	7543	0.014
Murska Sobota	0.835	14811	0.792	12469	-0.043
Ormož	0.863	12274	0.871	8295	0.008
Puconci	0.819	4309	0.796	4094	-0.023
Šalovci	0.814	1168	0.827	981	0.013
Veržej	0.894	987	0.887	832	-0.007
ALL TREATMENT AREAS	**0.844**	**49826**	**0.825**	**41481**	**-0.019**
Cankova	0.791	1411	0.775	1318	-0.016
Èrenšovci	0.802	3092	0.778	2761	-0.025
Dobrovnik/Dobronak	0.804	955	0.754	840	-0.050
Gornja Radgona	0.802	8992	0.839	5777	0.037
Kobilje	0.867	443	0.843	387	-0.024
Križevci	0.864	2395	0.865	2452	0.002
Lendava/Lendva	0.794	8268	0.762	7131	-0.032
Moravske Toplice	0.835	4232	0.820	3929	-0.015
Odranci	0.857	1243	0.842	1098	-0.014
Radenci	0.841	3873	0.850	3437	0.009
Razkrižje	0.836	946	0.868	867	0.032
Rogašovci	0.749	2299	0.750	2189	0.001
Sveti Jurij ob Šèavnici	0.804	1980	0.849	1932	0.045
Tišina	0.853	3027	0.802	2787	-0.051
Turnišèe	0.812	2506	0.802	2283	-0.010
Velika Polana	0.850	1053	0.811	976	-0.039
Kuzma	0.748	1112	0.754	1055	0.007
ALL CONTROL AREAS	**0.813**	**47827**	**0.808**	**41219**	**-0.006**

3.3.8 Summary of Case Study Results

The new econometric work carried out for these case studies of rail investments furthers the limited empirical evidence in this field by applying robust estimation methodology to a rich set of data across a range of applications. These approaches are based on household based employment so as such tell us about labour supply responses rather than movement to more productive jobs.

We use longitudinal data on these case study lines to control for unobserved zone/area fixed effects. Using a Difference in Differences approach we identify any additional change in employment of treated areas (subject to the rail investment) relative to that experienced in control areas to implement a robust 'quasi'random' approach to ex-post scheme evaluation.

Based on this work, we make the following observations:

- On the Stirling Alloa line we do not find a significant treatment effect; this could be due to the small sample size, the relatively short ex-post time horizon used (3 years) or the fact that as a lightly used line it is unlikely to yield large employment impacts. However we do find distance related effects, i.e. that a reduction in access distance in an area has a significant and positive association with employment levels. This effect is very small but suggests a 10% reduction in access distance is associated with a 0.27% increase in employment.

- In the Manchester Metrolink case study we find a positive employment impact associated with Phase 2 amounting to a 7.7% increase in employment all else equal. The new rail service formed part of a package of re-development initiatives in the area of East Manchester. Whilst we have used control areas within the re-development area it may be that the observed employment effects may not be exclusively attributable to the line itself as they are part of a package of complementary re-generation investments. We find no impact of Phase 1.

- In the Robin Hood Line case study we do not find a significant treatment effect. We do find a negative and significant relationship between station access distance (following the opening of the new stations on the line) and employment. A 10% reduction in station access distance is associated with a 0.07% increase in employment.

- On the Muska Sobota-Hodos line in Slovenia we could not identify a positive employment effect. This may be due to the coarser scale of aggregation at which the data is available and the spread of impacts between freight, commuter and intercity traffic. It could also be attributed to the 'two-way road effect' where better linkages between two areas lead to displacement of economic activity from one area to another, ie people can now commute out of an area to access opportunities elsewhere.

- Unfortunately we were unable to find an historic rail investment that was able to provide sufficient quality data that would permit econometric investigation within the scope of this study.

- We did set out to try and find some good matches between ex post analysis and NeTIRail interventions, but we were not able to identify them – either by intervention type or by country. Whilst transferring the results is an issue (from one country to another and from one scheme type to another), the analysis raises important points regarding caution about reading too much into employment impacts and where these occur they may need ancillary investment in land use change to facilitate the impact.

In summary, our evidence, taken across the range of UK based case studies is mixed. It does not identify significant treatment effects for those zones with access to the new station openings on the Robin Hood Line or on the Stirling Alloa line, or from improved service levels in the Phase 1 of the Manchester Metrolink case study. We did identify a positive employment effect for Phase 2 but as this is linked to complementary extensive re-development investments in the corridor it is rather case-specific. On the Murska Sobota-Hodos line in Slovenia we did not identify a positive treatment effect. With a different model specification we did identify a small but significant employment effect based on improvements in access distance to stations in the Robin Hood and Alloa case studies.

Transferability to NeTIRail-INFRA

It is hard to transfer these findings to the NeTIRail-INFRA business case studies. It was always going to be hard as the lack of data and suitable historic investments meant we have been forced to analyse rail investments that are not directly comparable to NeTIRail-INFRA innovations in the sense of the same type of intervention in the same country. Even with these difficulties if there had been some degree of consensus between the studies this would have led to some sense of robustness in any model put forward. The mixed results between historic investments however make this already difficult task even more challenging.

One result that does stand out is that with some model specifications some of the rail investments examined do not generate any employment impacts. This would suggest a lower bound for any estimate of employment change from a rail investment of zero change in employment. The broader literature identifies that transport is a necessary but insufficient condition for economic growth, and it may be that for the investments we have studied the other ingredients for growth are not present. The Manchester Metrolink investment is a good example of this – as the Phase 1 investment did not generate any discernible employment impacts, whilst the Phase 2 one which is linked to a coordinated investment strategy across more than just the rail sector finds positive impacts. This finding might be quite relevant in the context of the NeTIRail-INFRA case studies as the innovations are not part of a coordinated investment strategy encompassing transport and land uses (e.g. urban renewal).

With other model specifications we do find some employment impacts related to distance from the station, ie the closer to the station the larger the impact. But these changes are small. Furthermore they are associated with very large changes in accessibility (no station to having a station). The NeTIRail-INFRA innovations are not expected to deliver such changes in accessibility and therefore any employment change will be commensurately smaller. These findings also only relate to two of the four historic investments examined.

These mixed results and the associated difficulty in transferring the findings between countries and innovation types mean that the only result that we are comfortable transferring to the NeTIRail-

INFRA innovations' business cases would be a lower bound for the labour supply (employment) effect of zero.

3.3.9 Employment calculations

Based on our case study results a reasonable lower bound for the labour supply effects would be zero, given our treatment effects are not significantly different from zero.

For an upper bound (sensitivity) to our figures we adapt a model based on commuting costs from the UK Webtag Guidance on Employment effects, TAG Unit A2.3 (DfT, 2016). A reduction in commuting costs increases the real (or effective) wage received by workers which incentivizes more people to move from economic inactivity to become economically active. This methodology makes the following assumptions:

- Demand for labour is perfectly elastic, i.e. employers will employ an increased supply of labour at the prevailing wage rate
- People make decisions about employment based on wages net of income tax and that reductions in commuting cost increase the net wage.

Based on these assumptions the guidance recommends the change in employment, the Labour Supply Impact in terms of additional workers, can be estimated in the following way:

$$\Delta employment = \sum_i \sum_j \left| -\varepsilon^{LS} \left(\frac{\left(GC_{i,j}^{Before} - GC_{i,j}^{After} \right) \Omega_j}{(1-\tau_1) y_j} \right) W_{i,j} \right|$$

where

$G_{i,j}$ is the average round trip generalised cost of commuting from area *I* to area *j*
ε^{LS} is the elasticity of labour supply with respect to effective wages, and in the absence of other evidence is set as default to 0.1
$\Omega_j^{S,f}$ is the average annual number of round-trip commuting journeys per worker in scenario *S* in area *j* per year in year *f*
τ_1 is the average tax take, assumed to be around 30%
y_j is the average annual gross income/pay for workers in area j
$W_{i,j}$ is the number of workers in area I employed in area j.

3.3.10 Employment data requirements

The data required in each case study for these calculations is therefore:

- Measures of employment, GDP and generalised cost at matching spatial levels (zones)
- Numbers of workers living and working in each zone
- Number of commuting journeys per worker in each zone
- Generalised cost of each mode and modal share for each zonal OD pair

- Values of reliability time to convert to a journey time equivalent.
- Values of time to convert fare changes into a journey time equivalent

We might also seek localised measures of the labour supply elasticity, but in the absence of such data an elasticity of 0.1 should be assumed.

We found that employment data are available for EU countries, but the Turkish employment data is very aggregate making it unlikely that these impacts can be calculated for the Turkish case studies.

3.3.11 NeTIRail-INFRA line types

In principle the agglomeration calculations apply equally across all the NeTIRail-INFRA line types – as all can generate labour supply effects. From practical purposes however it is likely that only the lines that serve cities will generate enough traffic to have a material relevance to the business case in terms of additional employment impacts. This would suggest the employment calculations will be most pertinent to the busy commuter line type and less relevant to the low trafficked lines and the freight lines.

3.4 Output

3.4.1 Measuring the change in output

The change in output, i.e. GDP is a key economy metric for a transport . If we assume that all the additional output produced by more productive workers and new workers who have entered the labour market can be sold without affecting prices (i.e. no crowding out) then we can calculate this change relatively easily. The change in GDP is given by the sum of the increased output produced by business travellers who are now working instead of travelling (equals their time and reliability saving components of their user benefits) ($UB_{time+reliability}$), the increased output from workers who are now more productive due to increased agglomeration ($\Delta GDP_{productivity}$) and the output produced by new entrants to the labour market ($\Delta GDP_{employment}$.) Thus:

$$\Delta GDP = UB_{time+reliability} + GDP_{productivity} + \Delta GDP_{employment}$$

3.4.2 NeTIRail-INFRA line types

The identity presented above and the relevance of the economic output calculations is equally relevant to all the NeTIRail-INFRA line types: busy commuter line, low trafficked line and freight line.

4. Valuation of economy impacts

Economy impacts are only included in a cost benefit analysis in addition to user benefits if market failures exist. As discussed previously the market failures of relevance in the NeTIRail-INFRA business case studies are: agglomeration externalities affecting agglomeration gains; differences between prices and marginal costs of products arising from monopsonistic power) affecting increases in economic output; and income taxes, labour immobility or wage rigidity that create high levels of unemployment that affect changes in employment. We will treat each of these in turn.

4.1 Productivity due to agglomeration

The presence of agglomeration economies mean that the physical proximity of workers increases productivity of all workers. This is a positive externality and is therefore a form of market failure. The size of the externality associated with one worker being brought into physical proximity to other workers is the additional output (GDP) produced by all these workers. Given that the GDP impacts have already been calculated as part of the quantification of economy impacts (see section 3.2) the valuation of the agglomeration impacts ($Value_{agglomeration\ impacts}$) is trivial.

$$Value_{agglomeration\ impacts} = \Delta GDP_{productivity}$$

4.2 Increased output in imperfect markets

4.2.1 Price -marginal cost markups

Imperfect competition occurs where firms hold market power by engaging in product differentiation or becoming large relative to their market. Central to the argument of the empirical relevance of imperfect competition is evidence on price - marginal cost mark ups. There is clear evidence at international and industry level that perfect competition does not prevail. Badinger (2007) using data from 1981 to 1999 for 10 EU member states finds price-marginal cost ratios post introduction of the single market of 1.28 for manufacturing, 1.31 for construction and 1.37 for services. Christopoulou & Vermeulen (2012) find average price-marginal cost ratios of 1.37 across the Euro area (8 countries) using data from 1981-2004. There is significant variation by industry with markup ratios in manufacturing and construction much lower (1.18) than those found in services (1.56). Thum-Thysen and Canton (2015) looking at all EU member states from 1996 to 2013 find that service sector mark-ups have been decreasing. For comparison the Department for Transport in the UK uses an average price – marginal cost ratio of 1.2 (Department for Transport, 2014) as does New Zealand (Kernohan and Rognlien, 2011 p45).

4.2.2 Imperfect competition calculations

Clearly where such variation exists by nation and industry one ideally needs price – marginal cost margins that are specific to the NeTIRail-INFRA business case study locations. We have not been able to identify an all economy study for either Romania, Slovenia or Turkey. Konings et al. (2005) for manufacturing in Romania find a markup factor of 1.07, which is lower than that found for old Europe countries by Badinger and Christopoulou & Vermeulen. Unfortunately Thum-Thysen and Canton (2015) in their cross-EU study do not report markups for Slovenia and Romania for professional services – as the underlying data was missing from these countries. There is therefore a need to transfer findings from elsewhere to the NeTIRail-INFRA business case study locations. Given that markups vary by industrial sector and that the industrial sector split varies across European nations with more manufacturing and less services in eastern European nations vis a vis western European countries the approach to be adopted to derive an average price-cost margin is to use Christopoulou & Vermeulen averages for manufacturing and construction (1.18) and services (1.56) and weight them be the relevant nation state industry proportions.

$$Average\ price - marginal\ cost\ markup\ \left(\frac{P}{MC}\right) = 1.18\ \times\ Proportion\ of\ manufacturing \&\ construction + 1.56 \times\ Proportion\ of\ services$$

Following the UK Department for Transport's method (for a proof see Kernohan and Rognlien, 2005 pp118-121) the value of increased output under imperfect competition is given by:

$$Value_{imperfect\ competition} = E_d \times \left(\frac{P}{MC} - 1\right) \times UB_{time+reliability}$$

E_d is the elasticity of demand of goods and services and a value of 0.5 can be assumed in the absence of other data.

4.2.3 Imperfect competition data requirements

The data required in each case study for these calculations is therefore:

- Industry proportions for manufacturing & construction and services
- Elasticity of demand for goods and services (assume 0.5 if not available)

These data are available for EU countries, but the Turkish data is very aggregate making it unlikely that these impacts can be calculated for the Turkish case studies.

4.3 Increasing labour supply

4.3.1 Labour supply calculations

An increase in labour supply implies that the total number of people who are economically active increases. An increase in labour supply does not imply that unemployment will reduce. The conditions under which reductions in unemployment have a social value is discussed in the following section. Increases in labour supply create an additional welfare surplus to user benefits if market failure exists in the labour market. The market failure of most relevance is a labour tax. When earned income is taxed this affects the return from labour and implies that there is a 'wedge' between the perceived income of workers and the marginal product of their labour.

The additional (to user benefits) value of increasing labour supply under such conditions is the increase in the income tax received.

$$Value_{labour\ supply} = \Delta Labour\ Tax\ revenue$$

$$= Average\ Tax\ rate\ \times\ Gross\ earnings\ of\ new\ workers \times\ No.of\ new\ workers$$

For many economic impact studies the gross earnings of new workers is taken to be the average wage in the region.

4.3.2 Labour supply data requirements

The data required in each case study for these calculations is therefore:

- Number of new workers (from the employment model – see section 3.3.10 for data requirements)
- Gross earnings of new workers (which can be taken to be the average wage in the region if necessary)
- Average rate of taxation for earnings at the level of new workers to the labour market.

These data are available locally or can be derived from EU summary economic sources.

4.4 Reducing unemployment

4.4.1 Unemployment calculations

There will be welfare benefits to reducing the level of unemployment, however, just because a transport initiative creates employment does not mean that unemployment will reduce. This is because at frictional levels of unemployment (unemployment < 5%) then crowding out effects would mean that the creation of a new job will displace a job elsewhere. It is only at high levels of unemployment (>10%) that one would expect the creation of 1 job to reduce unemployment by 1 Boardman (2011 p105).

The first step in valuing a change in unemployment therefore is to estimate how levels of unemployment will alter if they have not done so already. Extrapolating the Boardman et al. (2011 p105) figures gives us the following relationship:

(a) Unemployment rate < 5%. No reduction in unemployment.

(b) 5% ≤ Unemployment rate ≤ 10%.

$$Proportional\ reduction\ in\ unemployment\ per\ job\ created = \frac{Unemployment\ rate - 5\%}{5\%}$$

(c) Unemployment rate >10 %. A 1:1 reduction in unemployment.

If transport displaces employment from one location to another then the net impact on unemployment would need to be estimated.

For each worker brought out of unemployment the social value is the difference between their reservation wage rate and the market wage. Unfortunately the reservation wage cannot be estimated. Following Boardman et al. (2011 pp107-108)[6] an approximation can be made by assuming that the unemployed are randomly distributed along the labour supply curve and that the labour supply curve passes through the origin. On average therefore the difference between the reservation wage and the market wage will be half the wage rate. The social value of bringing someone out of unemployment is therefore half the 'take-home' wage as detailed below:

$$\begin{aligned} Value_{reducing\ unemployment} &= 0.5\ \times' take\ home' wage\ \times reduction\ in\ unemployment \\ &= 0.5\ \times\ (1 - average\ rate\ of\ tax) \times gross\ wage \\ &\qquad \times reduction\ in\ unemployment \end{aligned}$$

[6] Boardman et al term this Measure E.

4.4.2 Unemployment data requirements

The data required in each case study for these calculations is therefore:

- The number of jobs that are created by the transport scheme (that are not filled by an increase in labour supply – see section 3.3)
- Unemployment rate in the areas where employment is created and if employment is displaced from where it is displaced from
- The gross wage rate for workers brought out of unemployment
- The average rate of tax for workers brought out of unemployment

These data are pertinent to the local areas of the NeTIRail-INFRA case study areas, and are available from EU sources – certainly for Slovenia and Romania.

5. Conclusion

5.1 Summary

Economic impacts of rail investments typically stem from improvements in accessibility based on changes in generalised cost. Sources of wider economic benefits (that are additional to transport user benefits) are increased productivity agglomeration, increased output in imperfectly competitive markets and changes in employment. The relevant market failures and transmission mechanisms for measuring these impacts and the associated valuation approaches have been outlined in this document.

In the main the proposals under consideration by NeTIRail-INFRA will improve the delivery of services through cost decreases and improvements in reliability. The initiatives are concerned with improvements to existing infrastructure rather than the delivery of new railways or new stations.

Improvements in reliability can be converted into generalised cost and associated economic impacts measured through associated accessibility improvements. Here we are talking about accessibility in its broadest sense rather than opening up new land for development or specifically aiming to change land uses which can lead to larger economic impacts.

Cost savings represent more of a problem for measurement in terms of wider economic impacts. Context is key here. Innovations that are likely to mainly generate cost savings to the rail infrastructure or operator and are not either passed on in terms of fare reductions or in terms of improved train performance will not generate any wider economic benefits. The degree to which these savings are passed on can be driven by the type of competition and institutional arrangements on the case study lines, ie pass-through, is more likely with competition or state-ownership rather than a private monopoly operation.

We have transferred models used elsewhere to capture the agglomeration impacts and imperfect competition effects. Suggested model parameters pertinent to Eastern Europe have been drawn from the literature and presented to give a set of models that can be used to estimate the wider economic impacts of the NeTIRail-INFRA innovations when tested in the case studies.

Our analysis of the employment impacts of four historic rail investments has given interesting but mixed results. We do find an employment impact when transport forms part of a package of urban re-generation investment. We also find some evidence that accessibility improvements form being nearer a rail station has an employment impact. These impacts have been hard to interpret in the context of the NeTIRail-INFRA innovations; partly due to the difficulty in transferring the results to the NeTIRail-INFRA innovations and partly due to the nature of the findings. They do however suggest a lower bound on employment effects of zero and would therefore suggest caution in any expectations that rail schemes may deliver large employment effects. We have however drawn on existing guidance for an upper bound based on responsiveness of labour supply to changes in wages net of transport costs.

In the course of our analysis we have generally found that data is quite limited. With respect to the NeTIRail-INFRA case study countries it is better in Slovenia and Romania but it is only in a very aggregate form in Turkey. Looking forward, these data limitations mean it is unlikely that the wider economic benefit methods presented in this deliverable can be applied to the Turkish case studies.

5.2 Further research

We have made a significant contribution to the discussion on the employment effects of rail investments. Unpicking the results found potentially offers some fruitful avenues for further research. The interaction between employment effects and rail only and rail plus land use investments is one area. A second area is focusing on the development of employment models that can be used easily in appraisal and transferred between projects – for example one based on changes in economic density.

In our literature search on parameters for the agglomeration effects and imperfect competition effects we also found that there is limited evidence on these effects in east European countries. There therefore remains the need to develop that evidence base too.

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